2240

STOPPING
WATER POLLUTION
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MISA
Municipal/Industrial Strategy for Abatement

BEST AVAILABLE TECHNOLOGY FOR EFFLUENT TREATMENT IN THE METAL CASTING SECTOR

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BEST AVAILABLE TECHNOLOGY FOR EFFLUENT TREATMENT IN THE METAL CASTING SECTOR

A Report for:

ONTARIO MINISTRY OF THE ENVIRONMENT
Industrial Section, MISA Office
Water Resources Branch
1 St. Clair Avenue West, 5th Floor
Toronto, Ontario
M4V 1K6

Prepared by:

BEAK ENGINEERING LIMITED
14 Abacus Road
Brampton, Ontario
L6T 5B7

In Association with:

HERITAGE REMEDIATION/ENGINEERING INC.
P.O. Box 51020
Indianapolis, Indiana
USA 46251

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EXECUTIVE SUMMARY

The Metal Casting Industry forms one of the industrial sectors for which effluent discharge limits are to be developed under the Ontario Government's Municipal and Industrial Strategy for Abatement (MISA) regulation. This report presents a review of water use and effluent management, treatment and recycle in the metal casting industry world wide to identify Best Available Treatment (BAT) options that could be implemented at plants in Ontario.

The Ministry of the Environment established five benchmarks as definitions of Best Available Technology as follows:

1. Best Plant in Ontario;
2. Best Plant in the United States;
3. Best Plant in the World;
4. Closest to Achieving Virtual Elimination of Toxics; and
5. Best for Achieving Non-Lethality to Rainbow Trout and *Daphnia magna* in Final Effluent.

MISA Monitoring information from the nine direct discharging metal casting plants was screened to determine a short-list of the contaminants of interest. This was done in order to focus the global search for BAT on technologies able to remove specific pollutants. Table 3.2 in Section 3.0 presents 28 short-listed substances comprising nine metals, suspended solids, oil and grease, nitrogen and phosphorus species, phenolics, cyanide, fluoride and several trace organic compounds.

The Ontario metal casting sector was sub-divided into three distinct groups during this study. Eight of the plants fall into either the Wet Processing or the Dry Processing Sub-Category. The Wet Processing group is categorized by the use of large quantities of water for wet dust collection, scrubbing of furnace exhausts, and slag quenching. The remaining plants use very little water for direct contact process applications. Haley

Industries Limited was isolated as a sub-category of its own because of its unique operation. Much of the process effluent at Haley is derived from nitric, chromic, sulphuric and hydrofluoric acid use and from X-Ray processing wastes.

The search for BAT candidate plants included Canada, the United States, Germany, Japan, Taiwan, China and Korea. Effluent limitations in effect for the metal casting industry were collected from these jurisdictions and are tabulated in Section 4.0. Detailed operating data obtained from eleven casting plants and one plant outside of the casting sector are summarized in this document in support of BAT recommendations.

Section 8.0 of the report presents the recommended BAT processes for each sub-category. A summary of the technology components, the predicted effluent quality and the capital and operating costs to General Motors and Ford in the Wet Processing Sub-Category are shown in Table 1. General Motor's facility was identified as the Best in Ontario (BAT 1) while the model plant for BAT 2-5 was identified as Foundry No. 1, a facility described in detail in Section 6.0. Options 1 through 4 presented in Table 1 represent sequential applications of demonstrated technology rather than performance from a specific plant. The BAT 2-5 model employs chemical assisted clarification of wet processing effluent followed by complete recycle of the process and cooling water flows via evaporative cooling towers. The small amount of blowdown from this system for control of dissolved solids represents about 2 m^3/t of metal melted and is close to a 98 percent reduction in total water discharge compared to the present situation at the two Ontario plants. The blowdown is biologically treated for removal of phenolics and is then filtered for reducing suspended solids. The last step is ion exchange for selective removal of divalent heavy metal ions such as copper, lead and zinc.

Table 2 presents a similar technology, effluent and cost summary for BAT in the Dry Processing Sub-Category. The majority of the water used in these plants is for non-contact cooling operations. Western Foundry and Canada Alloy were jointly identified as the model for the Best in Ontario (BAT 1) plant. BAT world-wide was defined as zero discharge of

TABLE 1: BAT OPTIONS - WET PROCESSING SUB-SECTOR

Plant/Option	Best in Ontario (BAT 1)	Option 1	Option 2	Option 3	Option 4	Best in World (BAT 2-5)
Technology	Clarification Partial Biological	Clarification Recycle Process	Clarification Recycle Process Activated Sludge Filtration Ion Exchange	Clarification Recycle Process Recycle Cooling Activated Sludge	Clarification Recycle Process Recycle Cooling Activated Sludge Filtration	Clarification Recycle Process Recycle Cooling Activated Sludge Filtration Ion Exchange
Predicted Performance						
• Flow Basis (m^3/t)	90	45	45	2	2	2
• TSS (g/t)	1,450	1,030	1,020	30	5.2	1.8
• Oil and Grease (g/t)	160	92	87	0.32	0.32	0.32
• Phenolics (g/t)	4.3	NA	0.014	0.004	0.004	0.004
• Copper (g/t)	0.51	0.30	0.30	0.02	0.02	0.002
• Lead (g/t)	2.7	0.23	0.006	0.06	0.06	0.006
• Zinc (g/t)	35	0.40	0.12	0.40	0.40	0.12
• Cyanide (g/t)	0.43	NA	0.009	0.008	0.008	0.008
Estimated Costs						
General Motors						
• Capital ($ x 1,000)	0	11,800	17,200	18,700	25,000	38,600
• O & M ($ x 1,000/y)	0	490	1,300	1,200	1,300	1,800
Ford						
• Capital ($ x 1,000)	920	9,300	12,600	14,800	17,900	26,300
• O & M ($ x 1,000/y)	70	240	800	620	670	1,000

Note: g/t refers to grams discharged per tonne of actual metal melted.

TABLE 2: BAT OPTIONS - DRY PROCESSING SUB-SECTOR

Plant/Options	Units	Best in Ontario (BAT 1)	Best in World (BAT 2-5)
Technology		Oil/Water Separation Partial Recycle	Oil/Water Separation Maximum Recycle Residues to Sanitary or Contract Hauling
Predicted Performance			
• Flow Basis (Direct Discharge)	m^3/t	4.8	0
• Oil and Grease	g/t	11	0
• TSS	g/t	18	0
• Aluminum	g/t	0.31	0
• Copper	g/t	0.037	0
• Zinc	g/t	3.3	0
Estimated Costs			
Kubota			
• Capital	$ x 1,000	990	1,400
• O&M	$ x 1,000/y	20	31
Canada Alloy			
• Capital	$ x 1,000	0	350
• O&M	$ x 1,000/y	0	(13)
Western Foundry			
• Capital	$ x 1,000	0	780
• O&M	$ x 1,000/y	0	(62)
Franklin Electric			
• Capital	$ x 1,000	290	240
• O&M	$ x 1,000/y	4	4
Richmond Die Cast			
• Capital	$ x 1,000	400	400
• O&M	$ x 1,000/y	6	6
Chrysler			
• Capital	$ x 1,000	580	750
• O&M	$ x 1,000/y	(126)	(176)

Note: g/t refers to grams discharged per actual tonne of metal melted.

process and cooling water with DuPage Die Casting providing one example of the demonstrated technology. Even plants with complete recycle of process and cooling waters produce small quantities of blowdown wastes. These can be discharged by agreement to local sanitary sewers or collected for contract disposal with or without concentration by evaporation to reduce the net volume and cost.

Haley Industries Limited is unique among the direct discharging plants in Ontario as it is a magnesium casting operation and employs several chemical finishing/milling sub-processes. Its effluent is different from other casting plant effluents. By definition Haley represents the Best in Ontario example of BAT. No other casting plant was found that was similar to Haley that had an effluent treatment process suitable to use as an example of BAT 2 through BAT 5. It is noted in the report that the magnesium casting plants in the United States producing castings for the aerospace industry similar to Haley all discharge to municipal sanitary sewers. None of the pretreatment processes employed equalled the treatment currently employed and/or under construction at Haley. A plant was identified outside of the casting industry which produces effluent which is similar to the effluent at Haley in many respects. Performance data from this facility were used as a basis for a model BAT for Haley. The technology model included biological treatment of sanitary, X-Ray and dye penetrant wastes, chemical reduction of hexavelant chromium, chemically assisted flocculation and coagulation for metal removal, air stripping of volatile organics, sand filtration for suspended solids and metal polishing, carbon adsorption for organics and ion exchange for metals. The predicted capital cost for this BAT option is \$2.8 million with any annual operating and maintenance cost of \$217,000.

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1.0 INTRODUCTION

1.1 Program Objective

This document presents a technical and economic information base intended for use in developing effluent regulations in Ontario for direct discharging plants in the Metal Casting Sector. The information has been developed by BEAK Engineering Limited and its sub-consultant, Heritage Remediation/Engineering Inc., based on a world-wide review of demonstrated effluent management practices within the industry.

The principle tasks completed as part of this undertaking were as follows:

- assemble a plant-by-plant summary of operations affecting water use, re-use, treatment and discharge at direct discharging casting plants in Ontario;
- use recently developed monitoring data to identify the contaminants relevant to the casting sector that can be controlled by existing technologies and which are of potential concern;
- obtain information on the design, performance and cost of "Best Available Technologies" for reduction of effluent quantity and pollutant discharge demonstrated at similar casting plants elsewhere in the world;
- select five or more of these technologies that could be applied to the Ontario plants;
- predict the expected performance expressed as effluent quantity and contaminant load for the selected technologies; and
- estimate the capital and operating costs to implement the selected technologies.

The Terms of Reference for this study established the following objectives for defining the five Best Available Technology (BAT) options:

1. Best Plant in Ontario;
2. Best in the United States;
3. Best in the World;
4. Closest to Achieving Virtual Elimination of Toxics; and
5. Best for Achieving Non-Lethality for Rainbow Trout and *Daphnia magna* in Final Effluent.

1.2 Background

In 1986, the Ontario Ministry of the Environment initiated the Municipal-Industrial Strategy for Abatement (MISA) Program to improve water pollution control in the province. The stated goal of the MISA Program is the virtual elimination of persistent toxic contaminants from all discharge to Ontario's waterways.

The MISA Program developed a two-phase, multi-year agenda which was to run concurrently but independently for nine (9) different industrial sectors. The Metal Casting Sector was one of these and the technical program for this sector was implemented through the efforts of a Joint Technical Committee (JTC) combining industry and regulatory representation.

Phase 1 of the MISA Program included a year-long effluent monitoring program between May 1990 and April 1991 at each of the ten direct discharging casting plants. This sampling program monitored flows and a long list of contaminants potentially significant to the industry sector. All discharges entering surface waters including process, combined, cooling and storm runoff were monitored.

Phase 2 of the MISA Program involves the development and implementation of regulations. One of the first activities in this phase is the development of several examples of Best Available Technology for reducing contaminant discharge using the Phase 1 MISA monitoring data and a global review of effluent management systems operating at similar plants. It is this technical review which is the subject of the present report. The setting of specific regulations or the identification of parameters to be regulated is beyond the scope of this work.

The MOE published a document entitled, "MISA Issue Resolution Process - Issue Resolution Committee Report" in June 1990 which attempted to clarify definitions of terms, procedures and technical scope for the key MISA issues (MOE, 1990). It was intended that this document would provide a consistent framework and reference for all nine industrial sectors in Ontario during the review of BAT.

The issue resolution document was used as a central reference throughout the course of preparing this study and the guidelines cited in the document were used as much as was practical. Several of the guidelines and the definitions of BAT which affect the scope of the present work are summarized below.

Effluent Sources of Interest

Process effluent, once-through cooling water, stormwater and combined effluents discharging to surface waters are all of interest for potential regulation under MISA. The focus for stormwater should be from outdoor processing or stockpiling areas and from developed non-processing areas (e.g., parking lots).

Sector Subcategories

The Metal Casting Sector could be divided into sub-sectors if warranted for BAT purposes if process effluent characteristics differed significantly from one group of plants to another.

The differences could be caused by differences in manufacturing processes, plant age, type of contaminants present or many other factors. The guidelines state that subcategories should be established only when this could lead toward more stringent limits and that subcategories should contain a minimum of two plants, if possible.

Available Technology

An available technology can be changes in production processes, in-plant controls, effluent treatment steps, best management practices or any combination of the above. These must be found in the metal casting industry somewhere in the developed world or in use at a plant which produces untreated effluent similar in character to the effluent in one or more of the casting sub-sectors.

To be considered "demonstrated", operating data must be available suitable "to predict with a reasonable degree of confidence, the reliability of the technology and the performance ... in the sector or sub-sector, given the expected variability among plants". There is also a requirement that demonstrated technologies be capable of successful retrofitting into existing Ontario plants.

Best Available Technology

The selection of BAT from the list of demonstrated technologies including Best Management Practices (BMP) should consider primarily the ability to remove the contaminants of interest and secondarily, the ability to:

- achieve a non-lethal effluent for rainbow trout and *Daphnia magna*; to
- maximize recycle, re-use and reduction, and minimize contaminant transfer; and to
- maximize water conservation.

The following sections of this report present examples of demonstrated available technologies and select a short list of BATs based on the preceding definitions and guidelines.

1.3 Metal Casting Sector

1.3.1 The Industry

The following brief summary is provided as a general introduction to the remainder of the report.

The metal casting industry is defined by the pouring or injection of molten metal into a mould, with the cavity of the mould forming the basic shape of the finished product.

There are close to 300 metal casting plants in Ontario ranging from small plants producing a few hundred kilograms of cast product per day, to large plants producing hundreds or thousands of tonnes per day. The large majority of metal cast in Ontario is ductile iron or grey iron used for engine blocks, crank shafts and other automotive parts or for industrial equipment such as pump casings. Aluminum or aluminum alloy accounts for most of the remaining metal cast in the province, the products of which are used throughout the spectrum of manufacturing industries including automotive and aerospace.

Stainless steel and magnesium casting also occurs but the contribution to the total sector is small.

There were only ten direct discharging metal casting plants in Ontario at the beginning of the MISA Regulation Monitoring program and half of these were partially serviced by municipal sanitary sewers. All other plants were either totally serviced by municipal sewers or were completely dry operations.

1.3.2 Basic Processes

The following is a brief list of the main processing areas that can be found in casting plants:

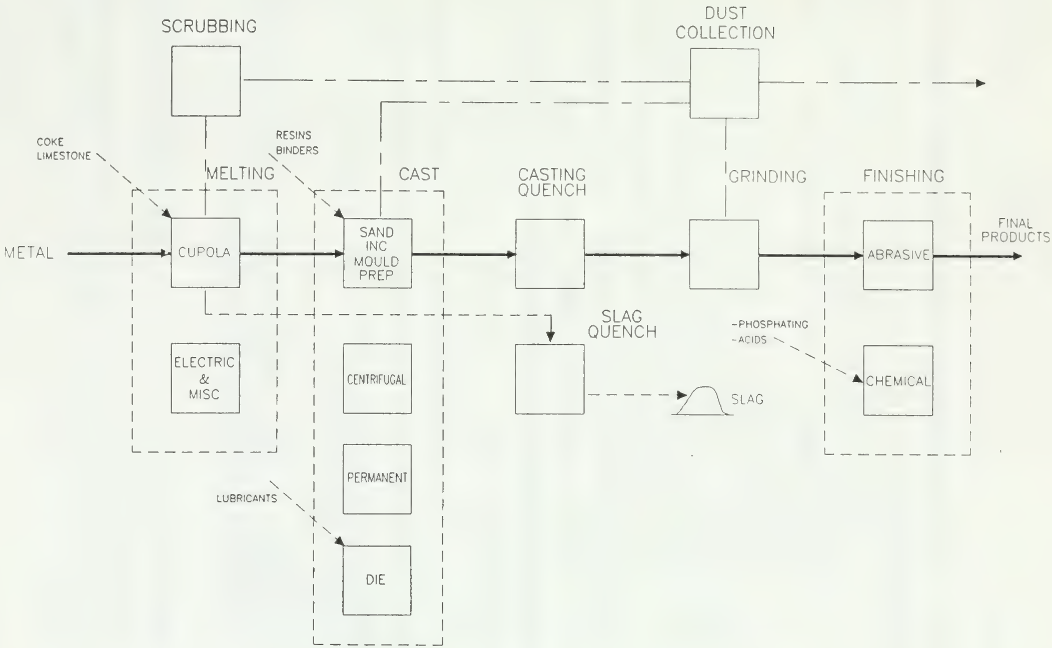
- Metal Melting;
- Casting;
- Dust Collection and Scrubbing;
- Slag Quench;
- Casting Quench and Cleaning;
- Sand Re-Use and Reclamation; and
- Grinding and Finishing.

Drawing No. 285 presents a generalized block flow diagram of metal casting process steps. This should help in putting the following casting process operations in proper perspective.

Metal Melting

Metal is melted in an array of different furnaces including cupolas, reverberatory, electric arc, induction and crucibles. The last four use either electrical energy or gas burners to heat and melt the pure metal before pouring into moulds. Little or no water comes into contact with these processes, except for non-contact cooling.

Cupolas are in a class of their own as large volumes of water are needed for non-contact cooling as well as contact cooling where water and cupola exhaust come into direct contact. The cupola furnace is a tall vertical cylindrical furnace having a steel shell, lined with refractory and equipped with a wind box and tuyeres for injecting air. A charging opening is provided in the upper zone into which scrap metal, coke, limestone and other materials are introduced by a skip loader. Combustion occurs inside the cupola. The melted metal and slag flow to the bottom of the cupola toward a pouring hole and the hot gases and fly ash exit the top where they are quenched and then scrubbed in a wet cap and a venturi scrubber.



METAL CASTING OPERATIONS
BLOCK FLOW

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO 91-5070-285

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Casting

Molten metal is either poured into a mould or injected into dies generally using one of the following techniques:

- Sand Casting;
- Centrifugal Casting;
- Permanent Moulds; or
- Die Casting.

There are many techniques and variations in sand casting. The "green sand" method is the most widely used in which a mould of moistened sand is packed by mechanical pressure into a box into which the impression of the desired casting is pressed. Shell moulds and core moulds are used to form more intricate castings. Sand is the basic mould material but organic binders and resins are added before the moulds are baked or specially treated with hardening agents.

The preparation of sand moulds, the hardening or curing, and the materials handling associated with collecting and re-using spent casting sand in foundries requires a large percentage of the total plant area. This area is usually dry and produces no liquid effluent except from air scrubbing systems.

The other casting techniques use permanent metal moulds to form the cast shape rather than sand. Centrifugal casting is common for pipe manufacture.

Molten metal is usually forced by pressure into a mould in a die casting operation. The major sources of contaminated wastewater in a die cast plant originate around the die cast machine through hydraulic oil leakage and drippings from die lubricants and sprays.

Dust Collectors and Scrubbers

Most foundries have some form of air cleaning/dust collection system. Dust collection equipment is extensive in most foundries using sand-based casting in order to remove the airborne fines that originate from shake-out, screening, sand reclaim, core forming and metal pouring areas. These dust collectors can be wet or dry and the water flows to wet collectors can be very high, often accounting for the majority of process effluent.

Cooling and scrubbing of the exhaust from cupolas is the only other major user of process water in most foundries. The water is needed for cooling the large gas flows from 800-900°C to between 50 and 60°C and then for removing the large mass of entrained particulates.

Slag Quench

Cupolas produce a relatively large, continuous flow of molten slag which is solidified and cooled through direct contact with water sprays and a water filled quench tank. Some plants air-cool and solidify slags dry without quenching, although these are the exceptions.

Casting Quench and Cleaning

Some hot metal castings, in particular die cast aluminum, are cooled by sprays or by immersion in water filled quench tanks. Quenching is not a common process at Ontario plants and only two of the ten direct discharging plants have a quenching operation. Occasionally the castings are rinsed to remove oils and greases in a water-based process prior to flushing. This process is also uncommon in Ontario.

Sand Re-Use and Reclamation

Sand castings are used once only as they are broken when the cast metal is removed from the mould. The hot sand is collected under the casting shake-out areas, screened, cooled and recovered for re-use in green sand mould preparation. This sand is generally not used for core or shell moulds unless it is first refined through a "reclamation" process which involves heating or other steps designed to remove carbonaceous material and impurities.

Most foundries produce a quantity of casting sand requiring disposal as a result of the inability to recycle sand endlessly into all mould and especially core operations.

Grinding and Finishing

Once removed from the moulds, castings often require trimming and grinding to remove flash and to polish surfaces. There can be dry operations for coarser finishes using shot blast or wet operations for finer finishes using grinders and sanders with fine abrasive. There is little water use and few liquid discharges from these operations.

1.4 Report Format

The following sections of this report describe the procedures used in identifying potential BAT plants and in contacting those of interest for operating information. Section 4.0 summarizes the information on regulatory requirements collected during the BAT search. The Ontario plant profiles are described in Section 5.0. The Ontario MISA Monitoring Data are also tabulated in this section and the list of contaminants of potential concern in Section 3.0 is developed from this.

Summaries of individual plants contacted or visited outside of Ontario are presented in Section 6.0 by sub-sector. Effluent discharge by process, cooling and stormwater discharges are presented along with contaminant discharge data.

A general discussion of available effluent treatment technologies by treatment process type is provided in Section 7.0.

The proposed BAT candidate technologies by sub-sector are presented in Section 8.0 along with the predicted performances. Costs for implementing BAT at each Ontario plant are discussed in Section 9.0.

Best Management Practices are discussed in general terms in Section 10.0.

1.5 Data Presentation

There are numerous occasions in this report where full-scale operating data from casting plants are presented or summarized. Some of these data originated at Ontario plants from the MISA monitoring, while other data were obtained from plants in the United States and Asia. Procedures for "Monitoring Data Analysis" described in the Issues Resolution Committee Report, page 21-56, were used in collating and statistically evaluating these data sets (MOE, 1990). The procedures included specific instructions on how to record values near and below detection limits for calculating average concentrations and loads and in determining variability factors.

2.0 INFORMATION COLLECTION AND REVIEW

2.1 General Approach

A modified "80/20 Rule" was the approach taken in identifying suitable technologies and candidate BAT casting plants and in collecting and assembling performance data. Approximately 20 percent of the time budget was allocated to the world review and the general search for plants of interest with the remaining 80 percent used for direct follow-up, information collection and site visits to specific plants. In this way, the time and budget was put to best use and no critical requirements were missed. It is understood that the world search for demonstrated technologies could not be 100 percent thorough and rigorous.

2.2 Ontario Plant Information

A file of technical information for each of the ten affected Ontario casting plants had been developed by MOE during the two to three year period prior to the present study. Each casting plant had submitted a substantial package of information referred to as the "Initial Report" to MOE comprising flow sheets, site plans and data on production processes, chemical use, wastewater generation and treatment.

BEAK examined this file information at MOE's offices prior to making further direct contact with the plants.

The file data at MOE also included several relevant government initiated studies which were reviewed. These included two Environment Canada reports/draft reports on priority substances in the Canadian metal casting industry in general and a specific three plant evaluation of treatment effectiveness (Environment Canada, 1991(a) and 1991(b)).

The MISA Regulation Monitoring data for the Casting Sector plants was obtained in MOE's standardized report formats, initially for the first six months of data and ultimately for the full twelve months. This was used as the basis for assessing the contaminants of concern and the current treatment performance and discharge status by plant.

Site visits were arranged with each of the ten direct discharging plants plus one additional plant as a case of special interest. Written requests were made to each plant in advance of the visits for information that was not available from MOE files needed in the present study or for reproductions of data previously submitted. Information requested of and received from the majority of plants included the following:

- production during MISA Monitoring period (e.g., metal melted);
- melting capacities by furnace;
- technical data on the number, type and operation of wet dust collectors and scrubbers in use;
- confirmation of water use, re-use, treatment and discharge practices;
- information on cost of services and operating labour;
- requests for in-house reports on water conservation and effluent treatment studies; and
- general information on waste by-products and disposal.

Some plants were re-contacted to discuss hypothetical methods of implementing the proposed BAT options in order to receive feedback before, during and after the process of estimating capital costs.

2.3 Global Search Methodology

2.3.1 Search Focus

The focus of the global search for BAT in the metal casting sector was to identify specific model plants with similarities to the Ontario based plants as opposed to an exhaustive review of individual treatment processes or technologies. The geographic focus specified by MOE was limited to Canada outside Ontario, the United States, Mexico, Germany, Taiwan, Korea and Japan.

2.3.2 Personal Contacts World-Wide

An initial list of approximately twelve potential BAT candidate plants in the United States was assembled based on the personal knowledge of Heritage staff; particularly that of Dr. Jim Etzel. Further personal contacts of Dr. Etzel's were identified in each of the countries of interest outside Canada and the United States as summarized in Table 2.1. These individuals were contacted and asked for their assistance in identifying local plants relevant to this investigation.

Most of the people identified in Table 2.1 are directly or indirectly involved in the metal casting industry or are wastewater treatment specialists with casting plant effluent experience. Several of these contacts had studied in the United States and were familiar with some of the better effluent management systems at foundries in North America. This provided a degree of assurance that the project team's request for candidate plants for BAT would be interpreted with the appropriate perspective.

Table 2.1 lists only those individuals contacted who responded in some useful manner to the study team's inquiries. Numerous additional inquiries were made for which there was little or no response.

TABLE 2.1: WORLD-WIDE CONTACTS TO IDENTIFY CANDIDATE PLANTS

Country	Individual	Affiliation
Mexico	Mr. George Kitkowski	Industrias Fronterizas CMI
Korea	Mr. N.D. Cho	Korean Foundrymen's Association
Taiwan	Dr. T.K. Chang	National Taiwan University
	Dr. D.H. Tseng	National Central University
China	Mr. He Di Jiang	L.B. Knight - Shanghai
	Chui Zhong Li	Shanchuan Machine Tool
Japan	Mr. T. Tashiro	Nippon Imono Kyokai
	Mr. Hideo Ishikawa	Toyota Motor
	Mr. Yoshiaki Takemoto	Tohoku Mitsubishi
	Mr. Tsunehito Kamino	Mitsubishi Heavy Industries
Germany	Mr. Hermann Matthies	Knight Wendling Consultants
	Mr. Heidenmeyer	German Environmental Protection Agency
	Mr. J. Kirsten	Aquatech
	Mr. Butsch	Handte & Stengelin

2.3.3 Additional North American Contacts

Various contacts with regulatory agencies, trade associations and chemical and equipment suppliers were made to complete the search for BAT technologies and plant sites in the United States and Canada. A general summary of these is presented in Table 2.2.

The contact with regulatory and state foundry associations was aimed primarily at identifying the availability of toxicity data and to ensure that obvious candidate BAT plants had not been overlooked in the preparation of the initial list.

TABLE 2.2: NORTH AMERICAN CONTACTS - GENERAL

Category	Organization	Individual
Regulatory Agencies	Environmental Protection Agency, Washington	Mr. Don Anderson (EPA Dev. Doc. Author)
	Michigan, DNR	Mr. Paul Zugger
	California Regional Water Quality Control Boards	Mr. Mark Anderson Mr. John Chang Mr. Alan Friedman Mr. Wayne Pearson
	Wisconsin, DNR	Mr. R. Polson
Trade Associations	American Foundrymen's Society	Mr. Gary Mosher
	Michigan Foundry Association	Mr. Forest Donnelly
	Wisconsin Foundry Association	Mr. Brian Mitchell
	California Foundry Association	Mr. Fred Simonelli
	North American Die Casting Association	Mr. Paul Burnhart
	Canadian Foundry Association	Mr. Don Kennedy
Suppliers	Ion Exchange Resins	
	• Rohm & Haas	Mr. Vincent Tan
	• Dow Chemical	Ms. Phyllis Ferris
	• Tetra Technologies	Mr. Erwin Higgins
	• Alcoa Separations	Mr. Brad Ahlgren
	• Kinetico	Mr. Robert Hall
	Carbon Suppliers	
	• Calgon Carbon	Mr. John McMannus
	• Weststates Carbon	Ms. Sandi Marshall
	• Tigg Corporation	Ms. Amy Bartek
	Silver Recovery Systems	
	• Agmet	Mr. Mike Kopanon
	• Pace International Corp.	Mr. Bob Kreiman

Carbon adsorption for phenol removal and ion exchange for copper, lead, and zinc removal were two processes found in use at several BAT candidate plants. The BAT (Ontario) plant was found to employ biological treatment for phenol removal. Major resin and carbon suppliers were asked for installation lists within the metal casting sector to determine the extent of the technology use. A similar review of suppliers of ion exchange systems for removal of silver from photo-processing wastes was made to address a special waste management issue at Haley Industries.

The study team investigated several other information leads with respect to effluent management practices in the Canadian industry. For example, the progress of a federally sponsored review of the metal casting industry was reviewed informally with Environment Canada. A recent trip report to Japanese casting plants made by members of the Sand Reclamation Committee of the Canadian Foundry Association was reviewed to see if it contained any reference to water management and effluent treatment (CANMET, 1991).

BEAK's efforts to survey the Canadian Industry for potential BAT candidate plants focused on Ontario and Quebec. The 1991 Casting Source Directory identifies 190 metal casting operations across Canada, seventy-five percent of which are located in this region. This directory is known to be incomplete and it omits most die casting facilities but it accurately presents Ontario and Quebec as the geographical centre of the industry in Canada. The Scott's Industrial Directory (18th Edition) identifies close to 300 casting operations in Ontario under various categories (some plants appear in more than one category). BEAK contacted Canadian Foundry Association representatives (Ontario, Quebec and Head Office in Ottawa) and also contacted the Quebec Ministry of Environment (MENVIQ) for recommendations on casting plants with exemplary water and effluent management facilities. The general advice from those individuals contacted was that there were probably no plants employing effluent treatment processes any more advanced or unique than those at Ontario plants included in the study. Some Canadian companies are considering BMP issues in the design of new facilities as indicated by Western Foundry's new ductile iron plant in Brantford, Ontario. This facility commenced operation in September 1991 and was specifically designed to have no effluent discharge. Ford's new aluminum block casting plant for Windsor is adopting a similar zero discharge design philosophy.

2.3.4 Literature Sources

The United States Environmental Protection Agency (EPA) has published "Development Documents" which examine best available effluent treatment for a variety of industrial sectors including the Metal Moulding (Foundry) sector (EPA, 1985(a)). This document provided a specific source of possible BAT plants and some of the performance and variability information relevant to the present project. Several other Development Documents for industries which have some similarities in the effluents produced were also obtained and reviewed for sample technologies (EPA, 1982, 1982(a) and 1982(b)).

A general computer literature search was conducted to look for candidate plants using databases such as the National Technical Information Service (NTIS), World Aluminum Abstracts, Environmental Bibliography, Enviroline, Pollution Abstracts, Non-Ferrous Metals Abstracts and Compendex Plus.

2.4 Summary of Initial Search and Screening Activities

A list was developed of eighteen to twenty plants from which detailed operating, production and effluent treatment data were requested as the next step toward determining which were the most appropriate BAT candidates. All plants had been contacted originally by telephone and had indicated a willingness to provide some operating information. Most of these plants were then sent a detailed questionnaire requesting the information specified by MOE as necessary for a BAT plant. A sample of the questionnaire is provided in Appendix 1.

Thirteen plants responded with data which ranged from incomplete but useful to very thorough. The plants and their geographical locations are presented in Table 2.3. Four of the plants requested confidentiality of their data and have been coded as Foundries numbered 1 through 4.

TABLE 2.3: CANDIDATE BAT PLANTS

Company/Plant	Location	Main Metal
Waupaca (Plant 2 & 3)	Waupaca, WI	Grey Iron
John Deere	Waterloo, IA	Grey Iron
Foundry No. 1	USA	Grey Iron
Foundry No. 3	USA	Grey Iron
Foundry No. 4	USA	Grey Iron
Auburn	Auburn, IN	Grey Iron
Chrysler	Indianapolis, IN	Grey Iron
Mitsubishi	Kobi, Japan	Ductile Iron/Stainless
Foundry No. 2	USA	Aluminum
Chicago White Metal	Bensenville, IL	Aluminum
Industrias Fronterizas	Tamaulipos, Mexico	Aluminum
DuPage Die Casting	Niles, IL	Aluminum
Martin Marietta	Denver, CO	*

* Not a metal casting plant - special case.

Most of the plants in the survey produce grey or ductile iron. Four plants were aluminum casting operations. The Martin Marietta facility is an exception as it is not a casting plant. This is a defence based production facility with the Titon launch vehicle as the most notable product. It was included in the detailed information gathering step as the effluents generated at the site include a mixture of spent metal finishing and treating solutions, photographic developing rinses from X-ray processing and sanitary effluents which produces an effluent similar to that at Haley Industries. The review of this facility has been consolidated separately in Appendix 3 in recognition that it is not a casting operation and therefore cannot provide load based BAT limits (e.g., mass per tonne of metal).

None of the casting plants in Table 2.3 are located in either Korea or Taiwan. Attempts to identify examples of BAT effluent treatment plants in Korea through the team's industry contact in that country were unsuccessful. Verbal reports from contacts in both Korea and Taiwan stated that none of the plants in those countries would have effluent treatment and contaminant reduction processes as extensive as at least one or more of the plants already identified as BAT candidates in the United States.

The correspondence regarding BAT for effluent treatment at metal casting plants in Germany produced general information but no plants were willing to respond to the detailed questionnaire. It is understood that most casting operations are located in urban areas which are serviced by municipal sewers. The plants are relatively dry operations similar to North America and the disposal of small volumes of wastewater into sanitary sewers has not been an issue demanding sophisticated solutions. It was learned that there is a general move away from wet processing, including dust collection, to dry techniques partly for economic reasons and partly to avoid difficulties with environmental advocate groups in Germany.

Reference was made by the representative of the German EPA to one facility that was attempting to become a zero discharge plant by the use of an evaporation process to deal with concentrated blowdown from dust collection and scrubbing systems. This system is apparently not functioning effectively and the German EPA contact declined to identify the specific plant. There appeared to be little reason to pursue this further.

2.5 Site Visits

Several BAT candidate plants were considered of sufficient interest to merit site visits.

A total of five plants were visited as listed below:

- Martin Marietta, Denver;
- Foundry No. 1;
- Waupaca Plants 2 and 3, Waupaca;
- Foundry No. 4; and
- Foundry No. 3.

These were one day visits to tour the effluent control facilities and to collect operating, cost and production information not initially provided in the questionnaire responses. The Waupaca Foundry and Foundry No. 4 were visited by MOE's Sector Specialist for which detailed trip reports had been developed. These were not revisited by the project team.

3.0 CONTAMINANTS OF GENERAL CONCERN

3.1 Introduction

The MISA Monitoring Regulation Database contains results of analyses of well over one hundred different substances that were looked for during the twelve month monitoring program involving the Metal Casting Sector. For practical purposes it was necessary to focus on a shorter list of substances of general concern or general relevance to the sector before embarking on a world-wide search for treatment methods.

This section examines the database of analytical results generated by the effected Ontario plants to develop the necessary short-list. The review was completed solely for the benefit of organizing the work plan for this study. It is not intended that the substances selected for the short-list be interpreted as parameters recommended for regulation. Nevertheless, the general process of parameter screening presented in MOE's Issue Resolution Reports was followed (MOE, 1990).

3.2 Parameter Screening

Table 3.1 presents a list of all the parameters defined by MOE as "Priority 1 Contaminants" observed in the process or combined effluents at one or more of the plants. Priority 1 contaminants are defined as those substances which were found to be present at concentrations above the Regulation Monitoring Detection Limit (RMDL) for greater than 10 percent of sampling occasions at a confidence level of 95 percent (MOE, 1991). This is one method of creating a sub-set of those contaminants that were commonly found during the sampling.

Table 3.1 contains sixty-eight specific substances. The table was prepared based on all data from the nine direct discharging casting plants. A tenth plant, Canada Pipe, was part of the

TABLE 3.1: PRIORITY 1 SUBSTANCES - METAL CASTING
(12-Month MISA Monitoring Data)

Substance	Number of Plants	Substance	Number of Plants
Chemical Oxygen Demand	5	Phenolics (4AAP)	5
Dissolved Organic Carbon	9	M-Cresol	2
Total Organic Carbon	4	O-Cresol	2
(NH_3+NH_4)-N	5	P-Cresol	2
(NO_2+NO_3)-N	5	Phenanthrene	1
TKN	5	Fluoranthene	1
TSS	7	Naphthalene	1
Oil and Grease	9	Benzene	2
Total P	3	Toluene	3
pH	2	Styrene	1
Conductance	5	Chloroform	1
Cyanide - Total	4	Methylene Chloride	1
Fluoride	9	2-Methyl/C Naphthalene	1
Aluminum	9	M+P-Xylene	1
Antimony	1	O-Xylene	1
Arsenic	1	Benzylbutylphthalate	1
Beryllium	1	Bis(2-Ethylhexyl)phthalate	3
Cadmium	6	Di-n-butylphthalate	1
Chromium (+3)	3	Pentachlorophenol	1
Chromium (+6)	2	2,4-Dimethylphenol	2
Cobalt	1	Phenol	2
Copper	6	4-Nitrophenol	1
Iron	9	Biphenyl	1
Lead	4	1,1-Dichloroethane	1
Magnesium	9	Neoabietic Acid	2
Mercury	2	Abietic Acid	3
Molybdenum	2	Dehydroabietic Acid	1
Nickel	3	Isopimaric Acid	1
Selenium	1	Levopimaric Acid	2
Silver	2	Pimaric Acid	1
Thallium	1	Oleic Acid	1
Vandium	3	Chlorodehydroabietic Acid	1
Zinc	9	Total TCDF	1
PCBT	1	Total OCDD	2

monitoring program when it started but this plant has since been designated by MOE as a non-direct discharger. Data from this plant were not included in the table for this reason.

The next screening activity was to remove any Conventional, Non-Conventional or Non-Persistent Toxic contaminant by sample location where the long term average concentration was less than the Provincial Water Quality Objective or the RMDL.

The Issues Resolution Report (page 72-73) provides a concise definition of the substances that fall into these three categories. Abietic Acid, Neoabietic Acid, Levopimaric Acid and Chromium were removed by this review process. Each of these parameters was an issue in at most one plant (e.g., removal of single plant parameters constitutes the final screening activity).

The average concentrations of the substances remaining on the list were then compared to minimum concentrations that can be achieved by treatment techniques as summarized in the U.S. EPA's Treatability Database (EPA, 1989). Best Professional Judgement (BPJ) was used to ensure that treatability concentration limits from the database were used only when the treatment processes and the effluent quality were relevant to the effluents from the casting sector. A substance was removed from the list if the observed long-term average concentration during MISA Monitoring was less than the cited treatability limit. Toluene was removed from the list by applying this criterion as it was below the treatability limit at all but one plant.

A screening step was completed to remove substances for which there were obvious surrogates remaining on the list. Phenol and 2,4-Dimethylphenol were removed from the list as Phenolics (4AAP) were considered to be a suitable surrogate. Similarly, DOC was considered to cover COD and TOC, while TKN was covered by (NH_3+NH_4)-N.

Background levels in plant raw water were used to eliminate pH and Mercury. At both relevant plants, incoming pH was similar to effluent pH. At all but one plant, mercury concentrations in the effluent were similar to those in the raw water.

Conductance and magnesium were eliminated from the list as they were considered to be of little environmental significance.

The final short-list of contaminants of general interest presented in Table 3.2 includes parameters that were Priority 1 substances at two or more plants. This list contains twenty-four individual substances or groups of substances. Only fourteen of these were found regularly at four or more of the nine plants.

TABLE 3.2: CONTAMINANTS OF GENERAL INTEREST

Substances	RMDL* (mg/L)	Occurrence (No. of Plants)
General		
• Dissolved Organic Carbon	0.5	9
• Oil and Grease	1.0	9
• Total Suspended Solids	5.0	7
• (NO_2+NO_3)-N	0.25	5
• (NH_3+NH_4)-N	0.25	5
• Total Phosphorus	0.1	3
Inorganic Anions		
• Fluoride	0.10	9
• Cyanide	0.005	4
Metals		
• Aluminum	0.030	9
• Iron	0.020	9
• Zinc	0.010	9
• Cadmium	0.002	6
• Copper	0.010	6
• Lead	0.030	4
• Nickel	0.020	3
• Vanadium	0.030	3
• Chromium (+6)	0.010	2
• Molybdenum	0.020	2
• Silver	0.030	2
Organics		
• Phenolics (4AAP)	0.002	5
• Bis(2-Ethylhexyl)phthalate	0.0022	3
• M-, O-, and P-Cresol	-	2
• Benzene	0.0005	2
• Total OCDD		2

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* Regulation Method Detection Limit.

4.0 EFFLUENT GUIDELINES AND REGULATIONS

4.1 Ontario Regulations

In the Province of Ontario, effluent discharges to municipal sewer systems are governed by local sewer by-laws. If a plant discharges to a watercourse, then a Certificate of Approval (C of A) may be required specifying pollutant limits. The limits are set by the Ministry of the Environment of Ontario, subject to a review of the plant's facilities, effluent quality and the receiving environment.

Some examples of these discharge guidelines are provided in Table 4.1, taken from the C of A's for several Ontario plants. Parameters and their limits vary between plants due to the site-specific nature of the permitting process.

4.2 The United States

In the United States, Federal effluent guidelines have been developed for the Metal Moulding and Casting Industry. Each plant that discharges to surface water must apply to the EPA for a "National Pollutant Discharge Elimination System" (NPDES) permit. The industry was subdivided into five categories according to the primary metal cast at each plant. These categories comprised aluminum, copper, ferrous metals, magnesium and zinc castings.

Within each category, distinct manufacturing or air pollution control process segments that generate unique process wastewater streams were identified (e.g., dust collection scrubbing or casting cleaning). Based upon the Best Practicable Technology (BPT) and Best Available Technology (BAT) identified for the U.S. plants, each of these process segments was assigned an allowable mass loading in kg/tonne of metal poured and an allowed water use. Concentration based limits are back-calculated from this information.

TABLE 4.1: CERTIFICATE OF APPROVAL DISCHARGE LIMITS FOR ONTARIO-BASED PLANTS

		C of A Limits (mg/L) Monthly Average		
Parameter	RMDL (mg/L)	Haley Industries	General Motors	Ford[1]
BOD	-	1.63		
TSS	5.0	4.01	15	15
Phenols (4AAP)	0.002	0.013	0.02	Monitor
O/G	1.0	1.37		
NH_3-N	0.25	0.02		
Silver	0.030	0.00005		
Nickel	0.020	0.01		
Zinc	0.010	0.038		
Copper	0.010	0.0035		
Lead	0.030	0.0043		
Chromium	0.020	0.067		
Aluminum	0.030	0.11		
Iron	0.020	0.1		
Fluoride	0.10	0.65		
pH	-	6.5-7.5	Monitor	Monitor
Temperature	-	-	-	Monitor

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[1] Semi-annual metal scan required.

In the NPDES permits, both concentration and mass based limits are assigned a daily maximum and a maximum monthly average value. The concentration based limits are sometimes also assigned a maximum annual average. The permits are "tiered" so that different flow, mass and concentration limits are assigned to different production levels. All limits within a production range must be met consistently. To calculate how much of a pollutant a plant is allowed to discharge, the total is calculated based on the specific process operations in use. The same procedure is applied to effluent volumes.

Of the five subcategories in the industry, copper and zinc do not exist in Ontario as direct discharge plants. The magnesium casting sub-sector in the United States was left unregulated as "EPA [has] determined that the BPT options considered for the magnesium subcategory are not economically achievable for the subcategory as a whole. One of two plants was projected to close if even the most basic of treatment was used as the basis of BPT" (EPA, 1985(a)).

One problem with this format of regulation is that some process discharges are not regulated. Certain processes in the metal moulding and casting industry (e.g., impregnation rinsing, sanitary effluent, effluents from oily waste treatment (reclaim)) are not covered by the regulation because their use was not sufficiently widespread to allow the EPA to characterize the effluent quality or because the effluent source was not specifically associated with casting operations. Individual permit writers are left to their best professional judgement to establish technology based limits for these processes on a site-specific basis. Other discharges have been excluded from regulation because they are not related to a "process stream". For instance, the discharge of once-through cooling water has not been examined so the regulation is insufficient for regulating discharge of combined effluent.

Another problem with the U.S. regulation is it's complexity. The industry base is considerably larger in the U.S. than in Ontario. In order to encompass such a sizable industry, regulation development was forced to be highly complex and required a very large database. In Ontario, there is a much smaller direct discharging industry consisting of two large foundries and seven smaller ones. To produce a complex regulation based on the system in the United States to regulate such a small industry is unnecessary.

Examples of the discharge permit limitations for Foundry Nos. 3 and 2 are provided in Tables 4.2 and 4.3, respectively. The form that the NPDES permit takes is the responsibility of the permit writer. Loading and/or concentration limits may be imposed and the permit may be tiered to production at the discretion of the permitter. Foundry No. 3 has concentration and load based limits for some parameters but only concentration based limits for others and the permit has been tiered for different production ranges. Foundry No. 2 has concentration based limits for all parameters except phenols and does not possess a tiered permit.

4.3 Asia and Germany

BEAK contacted the environmental regulatory bodies of Japan and Taiwan. In Japan, there is one set of regulations which covers discharge of all industrial effluent. Table 4.4 provides an overview of limits which have been imposed on relevant parameters. In Taiwan, there is a set of industrial regulations specific to the "metal industries". These effluent standards are presented in Table 4.5. Note that the regulations in Taiwan are staged with the limits for cadmium, pH, COD, and TSS decreasing between the present and 1998.

The Japanese and Taiwanese limits are the same for most parameters. The Japanese regulate TSS to 150 mg/L while in Taiwan the limit is 200 mg/L but scheduled to be reduced to 30 mg/L by 1998. The other exception is oil and grease which in Japan is regulated to 35 mg/L while the limit is 10 mg/L in Taiwan.

TABLE 4.2: NPDES[1] DISCHARGE PERMIT LIMITATIONS FOR FOUNDRY NO. 3 (OUTFALL 002)

	Production Below 1,488 t/d				Production Between 1,488-1,985 t/d				Production Above 1,985 t/d			
	Load Limits (kg/d)		Concentration Limits (mg/L)		Load Limits (kg/d)		Concentration Limits (mg/L)		Load Limits (kg/d)		Concentration Limits (mg/L)	
Parameter	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum	30-Day Average	Daily Maximum
TSS	17.6	44.5	15	30	24.7	62.3	15	30	31.7	80.1	15	30
O/G	11.7	35.2	15	30	16.4	49.2	15	30	21.1	63.3	15	30
Cadmium	-	-	0.0025	0.03	-	-	0.0025	0.03	-	-	0.025	0.03
Copper	0.188	0.341	0.0283	0.0464	0.263	0.476	0.0283	0.0464	0.339	0.617	0.0283	0.0464
Iron	-	-	2.0	4.0	-	-	2.0	4.0	-	-	2.0	4.0
Lead	0.305	0.621	-	0.10	0.427	0.871	-	0.10	0.549	1.12	-	0.1
Mercury	-	-	-	0.0005	-	-	-	0.0005	-	-	-	0.0005
Zinc	0.435	1.15	-	1.0	0.608	1.61	-	1.0	0.785	2.08	-	1.0
Fluoride	-	-	-	5.0	-	-	-	5.0	-	-	-	5.0
Cyanide	-	-	0.10	0.20	-	-	0.10	0.20	-	-	0.10	0.20
Phenolics (4AAP)	0.286	0.816	-	0.1	0.397	1.14	-	0.1	0.513	1.48	-	0.1

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[1] National Pollutant Discharge Elimination System.

TABLE 4.3: NPDES[1] DISCHARGE PERMIT LIMITATIONS FOR FOUNDRY NO. 2 (OUTFALL 002)

	Load Limits (kg/d)		Concentration Limits (mg/L)	
Parameter	**30-Day Average**	**Daily Maximum**	**30-Day Average**	**Daily Maximum**
TSS	-	-	10	15
BOD_5	-	-	15	30
O/G	-	-	-	10
Ammonia				
• Summer	-	-	1.4	2.8
• Winter	-	-	1.6	3.6
Copper	-	-	0.07	0.14
Lead	-	-	0.04	0.09
Zinc	-	-	0.44	1.03
Phenols (4AAP)	0.12	0.34	-	-

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[1] National Pollutant Discharge Elimination System.

TABLE 4.4: INDUSTRIAL EFFLUENT DISCHARGE REGULATIONS FOR JAPAN

Parameter	Discharge Limits (mg/L)
BOD_5	120
TSS	150
O/G	35
Phenols (4AAP)	5
Cadmium	0.1
Lead	1.0
Chromium (Hexavelant)	0.5
Arsenic	0.5
Mercury	0.005
Copper	3
Zinc	5
Iron	10
Chromium	2
Cyanide	1.0
Fluoride	15

TABLE 4.5: EFFLUENT STANDARDS FOR METAL INDUSTRIES IN TAIWAN

Parameter[1]	To Meet the Standards at Present	1993	1998
Temperature (°C)	<35	<35	<35
pH	5.0-9.0	6.0-9.0	6.0-9.0
COD	200	100	100
Oil and Grease	10	10	10
Suspended Solids	200	50	30
Cyanide	1.0	1.0	1.0
Iron	10.0	10.0	10.0
Cadmium	0.1	0.03	0.03
Lead	1.0	1.0	1.0
Total Chromium	2.0	2.0	2.0
Hexavelant Chromium	0.5	0.5	0.5
Total Mercury	0.005	0.005	0.005
Copper	3.0	3.0	3.0
Zinc	5.0	5.0	5.0
Silver	0.5	0.5	0.5
Nickel	1.0	1.0	1.0
Arsenic	0.5	0.5	0.5

[1] Units in mg/L unless otherwise noted.

Environmental discharge regulations in Germany are for industrial wastewater in general and are presented in Table 4.6. The limits expressed in this table apply to all industrial discharges whether they are directed to a surface watercourse or to a municipal sewer. In general, the German regulations are an order of magnitude lower than the regulations in either Japan or Taiwan but they do not cover as many substances. The Germans also have mass and concentration based limits where the Japanese and Taiwanese limits are concentration based only.

TABLE 4.6: INDUSTRIAL WASTEWATER DISCHARGE REGULATIONS FOR GERMANY

Parameter	Discharge Limit	
	(mg/L)	**(g/hr)**
Arsenic	0.05	1
Lead	0.2	8
Cadmium	0.02	0.4
Chromium	0.2	8
Copper	0.3	12
Nickel	0.2	6
Mercury	0.005	0.1

5.0 ONTARIO CASTING SECTOR

5.1 Introduction

This section presents the plant-by-plant review of operations at the direct discharging casting plants in Ontario. Summaries of the MISA Monitoring data form the basis for contaminant discharges and treatment performance. Existing treatment technologies are described as are the major source-by-source uses of cooling water and process water. The summaries describe the treatment and disposal of process effluent, cooling flows, stormwater and sanitary wastes as separate classes. Discharge data are presented as concentrations and mass discharges (e.g., mg/L or g/metric tonne of metal melted).

A rationale for creating sub-sectors and identification of the Ontario BAT plant in each is also presented.

5.2 Ontario Plants

5.2.1 General Motors

Facility

General Motor's Foundry and Engine Plant in St. Catharines produces metal castings for automotive parts and assembles automobile engines. The plant was built in the early 1950's and produces grey iron and nodular iron castings using four cupolas and one induction furnace. Maximum theoretical capacity is about 5,100 metric tonnes of metal melted daily. As with most foundries this theoretical capacity is never reached and would not be sustainable.

A smaller aluminum die casting operation is located separate from the foundry in the engine plant. Maximum capacity for the two melting furnaces is 140 tonnes per day.

Moulding methods for the grey and nodular iron include green sand, heat set and cold set processes for cores and shell sand.

The General Motors plant is the largest casting operation in Ontario and occupies a site of greater than 50 hectares on the east side of the Welland Canal. There are approximately 16 hectares under roof between the two production areas.

Full production on five lines is normally considered to be 50/55 shifts per week, with melting furnace operations five to six days per week.

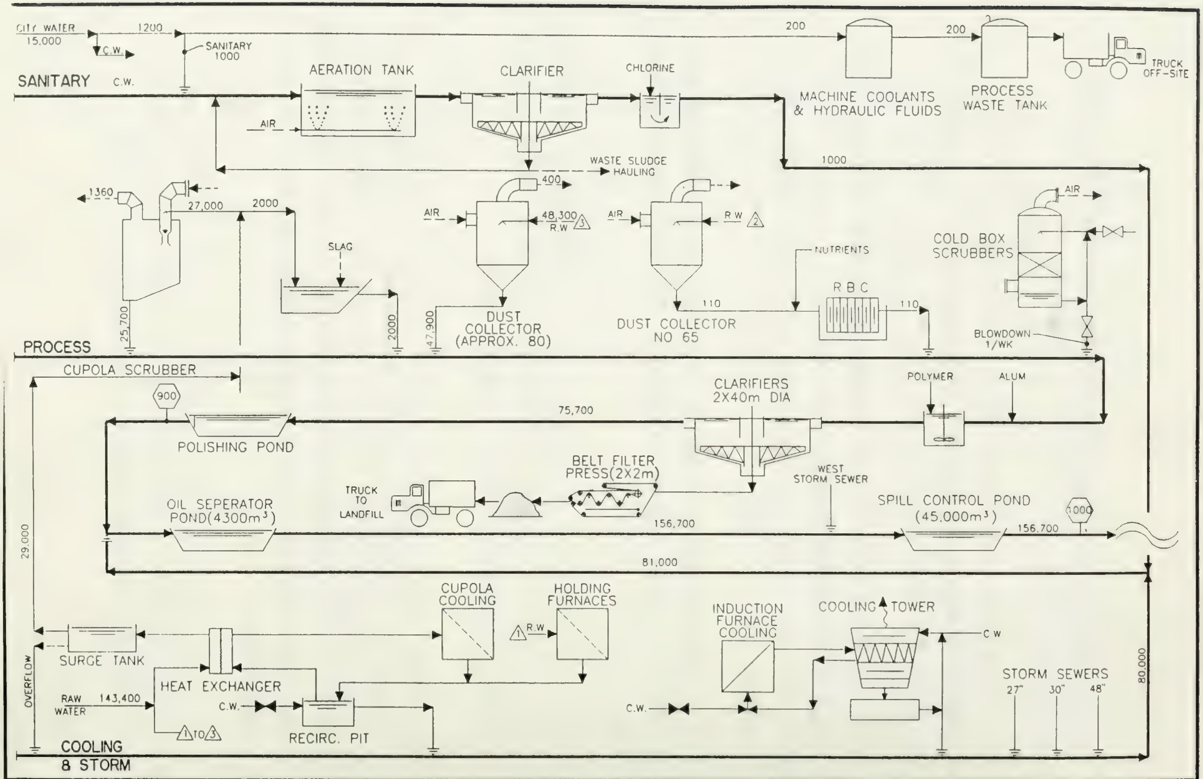
Water Use

General Motors uses 150,000 to 160,000 m^3 of water daily for cooling and process purposes. The majority of this comes by gravity from the Welland Canal and the balance is city water.

Process water use comprises about half the total water consumption for more than sixty wet dust collectors, the wet cap and venturi scrubbing on each of the four cupolas and for slag quenching. At present process water is all once-through use.

The majority of the remaining water usage is for once-through cooling purposes. This includes shell cooling for the cupolas, holding furnace cooling, air compressor cooling and a number of minor cooling uses. Cooling water for the induction melting furnace is on a closed loop with heat dissipation via a cooling tower and some of the once-through shell cooling water is used as a primary source of process water for the cupola wet cap and venturi scrubber.

Drawing No. 286 provides a Schematic Flowsheet of the water use at the foundry.



FLOW m³/d 143,400	GENERAL MOTORS, ST. CATHARINES EXISTING	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO 91-5070-286 DATE MAY\ 92

Wastewater Management

Approximately 72,000 m^3/d of process flow from the dust collectors, cupola scrubbers and quench tanks is collected in sumps and pumped to an overhead sluicing system leading to the effluent treatment plant. This consists of chemically assisted flocculation and coagulation of suspended material using alum and polymer in two large gravity clarifiers. Liquid alum is metered at a rate equivalent to 2,300 kg/d and polymer consumption is approximately 20 kg/d. A second polymer is used at a rate of 150 kg/d to assist in the dewatering of clarifier sludge on two twin wire belt filter presses processing about 260 wet tonnes of sludge cake per day in a typical five day week.

The process flow from No. 65 Dust Collector, which scrubs the exhaust from the hot coat muller, is collected separately and treated biologically for phenol removal in a Rotating Biological Contactor (RBC). This relatively small flow of 110 m^3/d contains a significant percentage of all the phenolics entering the process sewer and the RBC was installed in an attempt to reduce the phenolics concentration in the final combined effluent to the permit objective of 20 $\mu g/L$ or less. A review of phenolics monitoring from January to December 1988 concluded that the RBC was removing 65 to 70 percent of the phenol load to the unit (BEAK, 1990). This is discussed in Section 7.0.

Process effluent flows from the clarifiers through a polishing pond, the outlet of which is the flow monitoring station.

Cooling waters are discharged to four principal storm sewers each of which intercept the ditch that directs the process effluent from the polishing pond to an oil separator pond. This leads to a final shallow polishing basin called the Spill Control Pond. The total combined flow discharges from the Spill Pond to a backwater area of the Welland Canal.

Stormwater in three of the four storm sewers joins the process effluent flow upstream of the Oil Separator Pond.

Sanitary effluent is collected and treated separately in an activated sludge treatment plant and is then discharged to the combined effluent ditch upstream of the Oil Separator Pond.

Spent hydraulic fluids and coolants from the engine plant are collected in a process waste tank for shipment to an off-site treatment facility.

At present General Motors employs about six full time staff for operation and monitoring of process water and wastewater systems (e.g., 6 people x 1 shift/day x 5-5.5 days per week). The labour is divided evenly among the process effluent treatment, the sanitary system and dust collector/scrubber monitoring.

The main processing by-products which are sold or hauled for disposal off-site are as follows:

- Spent Sand (Black Sand) - 100,000 tonnes/year (dry)
- Core Scrap - 20,000 tonnes/year
- Cupola Drops (Refractory) - 20,000 tonnes/year
- Clarifier Sludge - 65,000 tonnes/year (wet)

Contaminant Discharges

Tables 5.1 and 5.2 summarize the twelve month MISA Monitoring data from General Motors for both the process effluent and the total combined flow. Results are expressed in terms of long-term average concentrations, mg/L and mass discharges; kg/d and grams per tonne of metal melted. Appendix 4 of this report presents a listing of the individual bioassay results which are summarized for the combined final outfall in Table 5.2.

TABLE 5.1: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: GENERAL MOTORS OF CANADA - STATION 0900 (PROCESS EFFLUENT)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	LTA (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	LTA (m^3/tonne)	
Flow	N/A	297	N/A	72,200	103,800	3,700	47.7	
				Concentration			Long-Term Average Load	
				LTA (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	51	0	3.21	15.0	0.80	163	247
O/G	1.0	151	88	1.43	6.0	1.0	71.3	108
TSS	5.0	344	116	8.86	98.0	1.0	433	656
(NO_2+NO_3)-N	0.25	10	1	0.46	0.68	0.20	25.2	38.1
(NH_3+NH_4)-N	0.25	12	0	1.07	2.02	0.21	60.1	91.0
Total P	0.10	50	28	0.18	4.1	0.01	9.6	14.6
Total Cyanide	0.005	12	2	0.0070	0.024	0.0030	0.42	0.64
Fluoride	0.10	12	0	0.28	0.49	0.14	15.7	23.8
Aluminum	0.030	153	0	0.66	4.18	0.0030	29.4	44.5
Iron	0.020	153	0	0.73	4.98	0.030	33.7	51.1
Zinc	0.010	153	0	0.66	2.99	0.001	34.7	52.5
Cadmium	0.002	153	100	0.0027	0.079	0.0011	0.13	0.20
Copper	0.010	153	76	0.0048	0.055	0.001	0.22	0.34
Lead	0.030	153	25	0.056	0.50	0.003	2.9	4.4
Phenolics (4AAP)	0.002	343	17	0.078	0.80	0.0002	4.2	6.4
Benzene	0.0005	12	2	0.00095	0.0017	0.00040	0.052	0.079
Bis(2-ethylhexyl)phthalate	0.0022	12	8	0.0049	0.022	0.0015	0.26	0.40

TABLE 5.2: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: GENERAL MOTORS OF CANADA - STATION 1000 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				LTA (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	LTA (m^3/tonne)	
Flow	N/A	365	N/A	135,600	182,800	69,100	89.6	
				Concentration			Long-Term Average Load	
				LTA (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	52	1	3.03	8.80	0.40	281	426
O/G	1.0	152	69	1.75	12.0	1.0	158	239
TSS	5.0	153	43	14.6	561.0	2.0	1446	2190
(NO_2+NO_3)-N	0.25	3	0	0.403	0.61	0.20	32.6	49.3
(NH_3+NH_4)-N	0.25	12	0	0.56	0.90	0.11	51.8	78.4
Total P	0.10	52	19	0.082	0.90	0.010	7.1	10.8
Total Cyanide	0.005	12	3	0.005	0.008	0.001	0.43	0.65
Fluoride	0.10	4	0	0.22	0.26	0.18	20.5	31.0
Aluminum	0.030	52	0	0.54	5.33	0.13	48.9	74.0
Iron	0.020	52	0	0.67	7.64	0.10	61.0	92.3
Zinc	0.010	52	0	0.39	3.41	0.035	35.1	53.2
Cadmium	0.002	52	40	0.0019	0.0060	0.0011	0.17	0.26
Copper	0.010	52	16	0.0057	0.042	0.002	0.51	0.77
Lead	0.030	52	18	0.029	0.36	0.010	2.7	4.1
Phenolics (4AAP)	0.002	152	6	0.051	0.40	0.0010	4.3	6.5
Toxicity		12		11/12	Non-lethal for Rainbow trout*			
		12		9/12	Non-lethal for *Daphnia magna**			

5.2.2 Ford

Facility

The Ford Windsor Casting Plant is located in downtown Windsor with the main foundry and Engine Plants 1 and 2 located south of Wyan Dotte Street, 200-300 m inland from the Detroit River. The foundry produces nodular and grey iron for automotive parts including engine blocks and other components for the engine assembly plants.

Two cupolas and an induction furnace provide a maximum theoretical metal melting capacity of 1,700 metric tonnes per day. Green sand, hot set and cold set techniques are used for mould and core production. Normal plant operation consists of melting sixteen hours per day, five days per week.

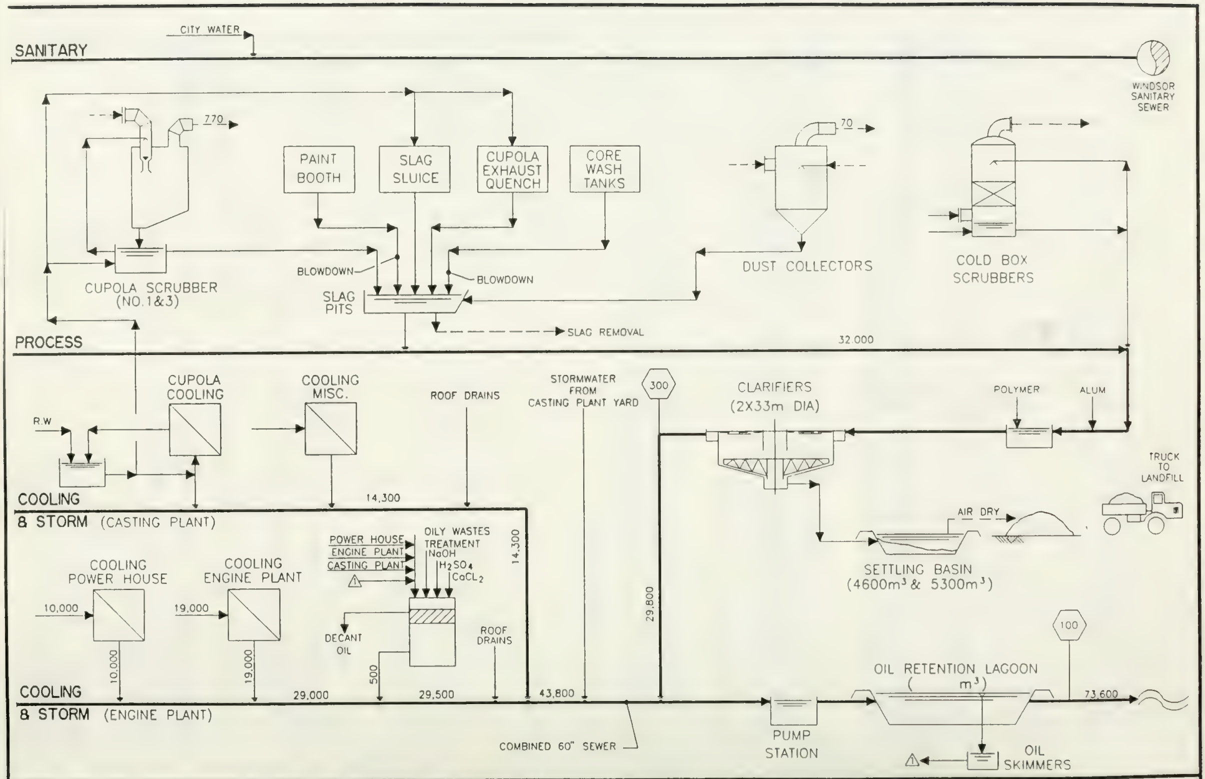
The main plant area occupies 8-10 hectares of land south of Wyan Dotte Street not including the power house and river front property used for sand off loading and open storage, water intake and effluent discharge.

Water Use

Drawing No. 287 shows a schematic of the water use and effluent management systems at Ford. Detroit River water is used for all but the sanitary facilities with a daily flow of 70,000-75,000 m^3/d.

Process water is required for the cupola exhaust quenching and venturi scrubbers, approximately 17 wet dust collectors, dust and slag sluicing, core washing and the paint booth. This represents about 40 percent of the total water use.

The balance of the water use is for cooling purposes. Cupola shell cooling, holding furnace cooling, and air compressor cooling are the main uses. Much of the water make-up for the cupola exhaust quench, cupola scrubbing, sluicing and slag quench comes from the cupola shell cooling effluent.



FLOW m³/d
10,000

FORD, WINDSOR
EXISTING

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-287

DATE
MAY\92

Wastewater Management

There are two process effluent treatment facilities at the Ford plant. One system is dedicated to treating oily wastes such as spent hydraulic fluids collected from the power house, the foundry and the engine plants. A chemical emulsion breaking treatment employs caustic soda, sulphuric acid and calcium chloride to separate all free and emulsified oils to be decanted to drums. This is operated on a batch basis with about 500 m^3/d of treated wastewater eventually discharged to the Combined 60 Inch Sewer which is the main plant sewer leading to the river.

The main process effluent flow is collected in one of two sumps and pumped to two circular clarifiers. Suspended solids removal is aided by the addition of about 190 mg/L of alum solution (e.g., 5.0 m^3/d) and 2-3 mg/L of polymer (e.g., 70 kg/d).

Clarifier sludge is pumped to one of two unlined sludge basins which are filled in a typical three-month cycle. Supernatant is decanted and the sludge is removed by a clam dredge and allowed to air dry until the material passes the Regulation 309 slump test. Final disposal is by contract hauling to a licensed landfill. A vacuum filter designed to mechanically dewater the sludge was installed several years ago but has not been used due to mechanical problems.

Treated process effluent flows by gravity from the clarifiers to join cooling water in the Combined 60 Inch Sewer. This directs the total flow to a low head pump station that lifts the flow into an Oil Retention Lagoon equipped with oil skimmers as shown in Drawing No. 287. Outflow from this basin passes through a flow measuring flume and monitoring station before being discharged to the river.

Stormwater from the roof drains and from the majority of the property is collected in the Combined 60 Inch Sewer and flows to the river via the Oil Retention Lagoon. Sheet runoff from a portion of the parking area at the extreme south end of the property flows into city storm sewers and runoff from the riverfront property flows directly to the river. Storm flows from all outside processing and/or material storage areas enters the Combined 60 Inch Sewer.

The capacity of the lift station at the Oil Retention Lagoon is adequate to handle all but a few peak storm flows each year.

Sanitary effluent is collected separately throughout the facility and discharged to the City of Windsor sanitary sewer system.

Manpower requirements at Ford for operating the effluent facilities comprise four to five man-days times five to six days per week. Two operators work one shift per day, six days per week at the oily waste treatment plant. The remaining labour is associated with the process effluent treatment system and sludge management plus routine monitoring of the wet scrubber and dust collection equipment. This excludes engineering and management time.

The spent sand, dewatered sludge and old cores, and cupola refractory account for about 36,000 metric tonnes per year of waste disposed of by contract hauling to landfill. The oily waste treatment plant recovers 1 cubic metre of oil daily.

Contaminant Discharges

Tables 5.3 and 5.4 are summaries of process and combined effluent data from the MISA Monitoring period.

5.2.3 Canada Pipe

Facility

Canada Pipe's casting plant in Hamilton produces ductile iron pipe and employs about 210 people. One cupola with a melting capacity of about 600 metric tonnes per day operates two shifts per day, five days per week during normal production. Melting rates

TABLE 5.3: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: FORD MOTOR COMPANY - STATION 0300 (PROCESS EFFLUENT @ SUSPENDED SOLIDS PLANT)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	359	N/A	29,800	46,900	2,090	46.4	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	50	0	3.83	8.10	0.90	188	121
O/G	1.0	151	81	2.0	24.0	1.0	98.2	63.1
TSS	5.0	354	1	18.7	188	1.0	916	589
(NO_2+NO_3)-N	0.25	12	0	0.83	1.51	0.34	40.6	26.1
(NH_3+NH_4)-N	0.25	12	0	0.54	0.82	0.025	28	18.0
Total P	0.10	50	28	0.027	0.13	0.01	1.2	0.80
Total Cyanide	0.005	12	5	0.047	0.103	0.003	2.5	1.6
Fluoride	0.10	151	2	8.27	35.0	0.10	436	280
Aluminum	0.030	151	1	1.60	9.05	0.010	81.4	52.3
Iron	0.020	151	1	1.17	3.08	0.020	59.9	38.5
Zinc	0.010	151	0	2.03	8.85	0.020	107	68.5
Cadmium	0.002	151	69	0.0070	0.031	0.001	0.36	0.23
Copper	0.010	151	78	0.020	0.14	0.010	0.98	0.63
Lead	0.030	151	39	0.13	0.46	0.010	6.8	4.4
Phenolics (4AAP)	0.002	349	22	0.54	1.69	0.0020	28.6	18.4
Benzene	0.0005	11	1	0.0011	0.0020	0.00010	0.56	0.036
Bis(2-ethylhexyl)phthalate	0.0022	12	6	0.0036	0.013	0.0015	0.19	0.12

TABLE 5.4: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: FORD MOTOR COMPANY - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 MAY 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	365	N/A	73,600	117,300	41,000	114	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	52	0	3.40	8.10	0.90	400	257
O/G	1.0	156	83	2.20	25.0	1.0	255	164
TSS	5.0	364	2	13.50	156.0	1.0	1590	1020
(NO_2+NO_3)-N	0.25	12	0	0.80	1.54	0.34	95.0	61.1
(NH_3+NH_4)-N	0.25	12	1	0.26	0.39	0.030	32.0	20.6
Total P	0.1	52	24	0.031	0.14	0.01	3.4	2.2
Total Cyanide	0.005	12	6	0.023	0.069	0.003	2.8	1.8
Fluoride	0.10	156	1	4.51	17.0	0.10	562	361
Aluminum	0.030	156	2	0.82	3.33	0.010	99.1	63.7
Iron	0.020	156	2	0.60	2.02	0.020	72.2	46.4
Zinc	0.010	156	1	0.89	3.39	0.010	111	71.6
Cadmium	0.002	156	107	0.0033	0.025	0.0010	0.39	0.25
Copper	0.010	156	126	0.013	0.050	0.010	1.5	0.94
Lead	0.030	156	57	0.054	0.21	0.010	6.5	4.2
Phenolics (4AAP)	0.002	360	24	0.22	1.09	0.0020	27.4	17.6
Benzene	0.0005	11	3	0.00046	0.0010	0.00010	0.056	0.036
Bis(2-ethylhexyl)phthalate	0.0022	12	7	0.0025	0.0057	0.0015	0.31	0.20

were between 200 and 300 tonnes per day during a 10-11 hour melting cycle at the time of this study.

Casting is by continuous, centrifugal and shell sand methods.

Canada Pipe embarked on a water reduction program coincident with the MISA Program. Some flow was discharged into a storm sewer shared by other industries in the area. This was the MISA Monitoring location until the water conservation program was successful in eliminating the discharge altogether.

This facility will not be subject to BAT Regulations developed under the present phase of the MISA Program as the plant is no longer classified as a direct discharger. A visit to this plant was arranged primarily to review the water reduction strategies that have been adopted during the last two years.

Water Use and Recycle

Canada Pipe receives its water from the City of Hamilton. It uses water in many different cooling applications and a few process applications, almost all of which have been altered to operate on recycle. The main water systems are as follows:

1. Evaporative cooling tower and recycle loop for cupola shell cooling.

2. Chemically assisted solids removal from cupola scrubbing water in a clarifier tank and then recycle to scrubber.

3. Evaporative cooling tower and recycle loop for casting machine cooling.

Slag is handled dry at Canada Pipe. It flows from the slag trough into buggies/ladles containing some sand where it solidifies. The buggies are taken outside and the contents dumped onto the ground and left to cool.

There must be some bleed streams from most recycle systems to avoid problems with excessive build-up of dissolved solids. Liquid is bled from the cupola scrubber loop with the sludge as it is removed from the clarifier. The entire sludge mass is solidified by adding cement to the point where the blend will pass the slump test to qualify as a registerable, non-hazardous industrial solid waste.

The blowdown from the cooling loop for the casting machines is used as a spray on the newly formed pipe which results in some evaporation with the dissolved solids adhering to the outside of the pipe mould.

The total flow to the sanitary sewer is not recorded so it is not possible to create an accurate water balance. Water meter readings during the last half of 1991 after the most recent water related changes were made indicated an average use of under 1,000 m^3/d. This is roughly 3-4 m^3/t of metal melted and much of this would be evaporated in one of the cooling towers.

Effluent Management

There are no effluent treatment facilities ahead of the discharge to the sanitary sewer. All "treatment" processes are internal to the plant to support the recycle systems.

5.2.4 Crowe Foundry

Facility

Crowe Foundry in Cambridge produces grey iron via two induction melting furnaces which, if both were operating, could melt about 60 metric tonnes per day. The plant uses green sand moulding and core production is mainly by the heat set process although some cores use the cold set method with sulphur dioxide. The plant produces castings for pumps, valves, agricultural equipment and other industrial hardware.

This plant is similar to Canada Pipe in that it eliminated its continuous discharge to a storm sewer through an in-plant water conservation program. It was subsequently inspected by MOE and deemed a non-discharging plant as far as the present BAT review of direct dischargers is concerned. The plant is connected to a local municipal sanitary sewer.

This facility was visited primarily to examine the effluent recycle in use for the wet dust collection system.

Water Use and Recycle

With the exception of the process water in the dust collector system almost all of the water used at the Crowe Foundry was in cooling applications. The dust collector effluent at Crowe was handled in a similar manner as the cupola scrubber flow at Canada Pipe. Effluent from the scrubber is collected in a clarifier tank from which settled solids are removed using a chain and flight sludge scraper arrangement. Alum and polymer assist flocculation and coagulation in the clarifier. The dust collector system has an air flow of 4,600 m^3/min and recirculates water at rate of 1 m^3/min.

A small bleed flow of about 1 m^3/d from the dust collector clarifier is combined with some city water to add moisture to the core sand in the sand muller. This practice has been in effect for several years. Another small bleed stream amounting to about 2 m^3/d is used in the sand cooler.

5.2.5 Franklin Electric

Facility

Franklin Electric manufactures motors for well water pumps. There is a small aluminum die casting operation as part of the plant for casting aluminum end bells and rotors. Two crucible furnaces have a combined theoretical melting capacity of 7.6 metric tonnes per twenty-four hour day but production is typically based on one shift per day and five days per week. The plant was melting between 1 and 2 tonnes per week at the time of the survey.

Usually six employees run the entire melting and casting operation which uses two die casting machines. Total employment at the plant has been 200 or more although this had declined to about 85 people by late summer 1991.

Franklin Electric is essentially a dry operation and produces little contaminated wastewater. However, there are dozens of different paints, enamels, solvents, hydraulic lubricants, grinding fluids, and phosphating solutions in various parts of the plant.

Water Use and Recycle

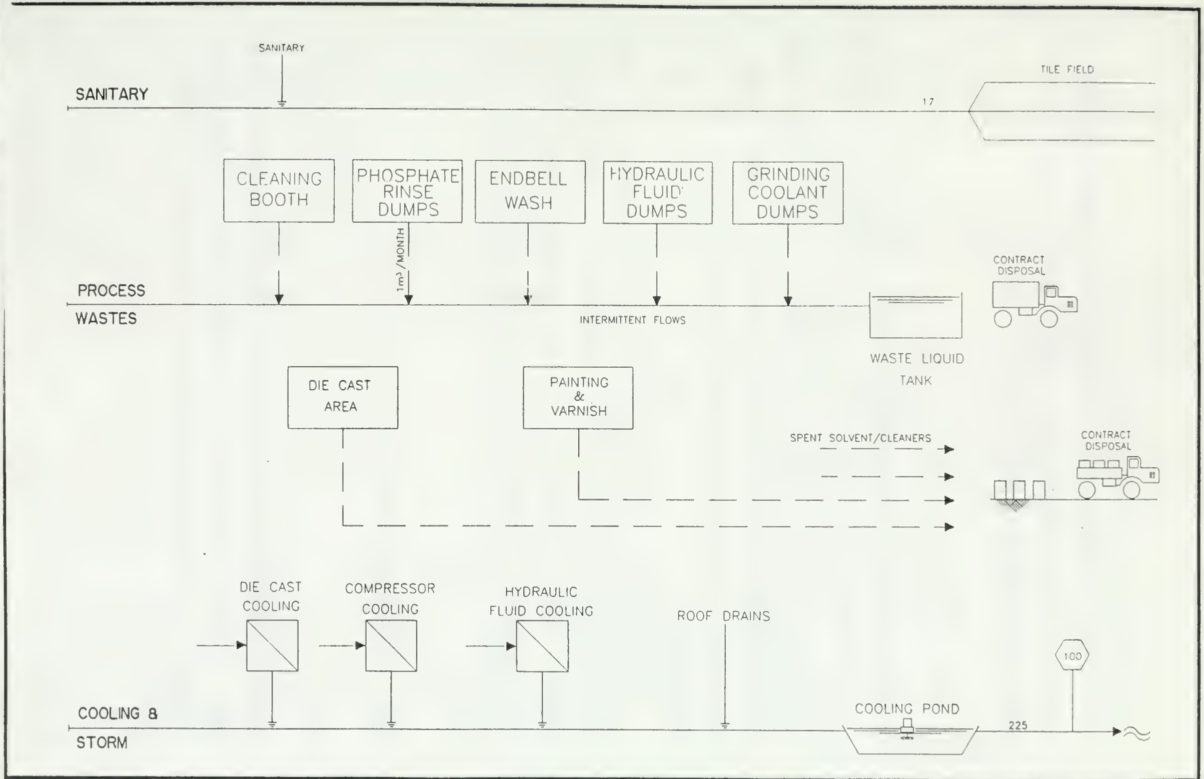
Franklin Electric is located in a rural area and relies on wells for its water supply. The only continuous water use is for non-contact cooling of the die casting machines, an air compressor and hydraulic fluids. There is no water recycle.

Effluent Management

Schematic Flowsheet No. 288 summarizes the water use and waste management practices at Franklin Electric.

Sanitary effluent is treated in a septic tile bed.

Cooling flows and roof drains discharge to a Cooling Pond which overflows to a small ditch which is designated by MOE as the receiving water. The pond has a liquid volume of about 5,100 m^3 and therefore provides approximately 23 days of retention. Fish are kept in the pond which is also equipped with a small home made aeration device to maintain dissolved oxygen concentrations.



FLOW m³/d
17 →

FRANKLIN ELECTRIC
EFFLUENT & WASTE FLOWS

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-288

DATE
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Process wastes are intermittent. These come from a variety of sources as identified in Drawing No. 288 and are collected either in the Waste Liquid Tank or directly in drums ready for hauling by contract for off-site disposal.

Contaminant Discharges

Table 5.5 summarizes the MISA Monitoring data collected at Franklin Electric. There is no way to determine whether the concentrations of any of the contaminants in the final discharge are higher than in the well water source as there were no intake water analyses. Suspended solids averaged almost 20 mg/L and are probably partly due to algae growth in the Cooling Pond. It is possible that the septic tile bed for the sanitary effluent contributes to the nitrogen and phosphorous concentrations as the tile bed is within a few metres of the Cooling Pond.

The dissolved organic carbon (DOC) concentration of 67 mg/L is much higher than would be expected in a well water sample. The BOD_5 of the effluent is not measured but a DOC of 67 mg/L could indicate a BOD_5 of 100-150 mg/L. It is possible that this too could be the result of seepage from the septic system or there could be small leaks in the non-contact cooling systems involving hydraulic fluids allowing glycol contamination of the cooling water.

5.2.6 Richmond Die Casting

Facility

Richmond Die Casting Ltd. produces custom aluminum castings largely for the automotive industry. The plant property occupies about 2 hectares of land in a small community a few kilometres east of Cornwall and has been operating at this location since moving from Montreal in 1968.

TABLE 5.5: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: FRANKLIN ELECTRIC INC. - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	12	N/A	277	426	201	644	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	14	0	67.1	97.9	17.2	48,100	20.7
O/G	1.0	14	8	1.82	5.20	1.0	1,160	0.50
TSS	5.0	14	5	19.3	77.6	5.0	14,900	6.4
(NO_2+NO_3)-N	0.25	5	0	1.77	3.11	1.13	1,440	0.62
(NH_3+NH_4)-N	0.25	5	0	0.28	0.35	0.086	184	0.079
Total P	0.10	5	2	0.42	1.55	0.050	372	0.16
Fluoride	0.10	5	0	0.54	0.61	0.50	419	0.18
Aluminum	0.030	14	0	0.16	0.65	0.030	128	0.055
Iron	0.020	14	0	0.24	0.97	0.060	188	0.081
Zinc	0.010	14	4	0.027	0.084	0.010	18.6	0.008
Cadmium	0.002	14	3	0.0052	0.029	0.0010	2.3	0.001
Nickel	0.020	14	3	0.031	0.13	0.010	16.3	0.007
Chromium (Hexavalent)	0.010	14	6	0.023	0.106	0.0030	18.6	0.008
Toxicity	N/A	4	N/A		All >100% for *Daphnia magna*.* ¼ <100% for Rainbow Trout.*			

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* See Appendix 4.

A reverberatory furnace has a melting capacity of 13.6 metric tonnes of aluminum per day and supplies molten metal to thirteen die casting machines.

The plant operates two shifts per day, five days per week and employs about 125 people.

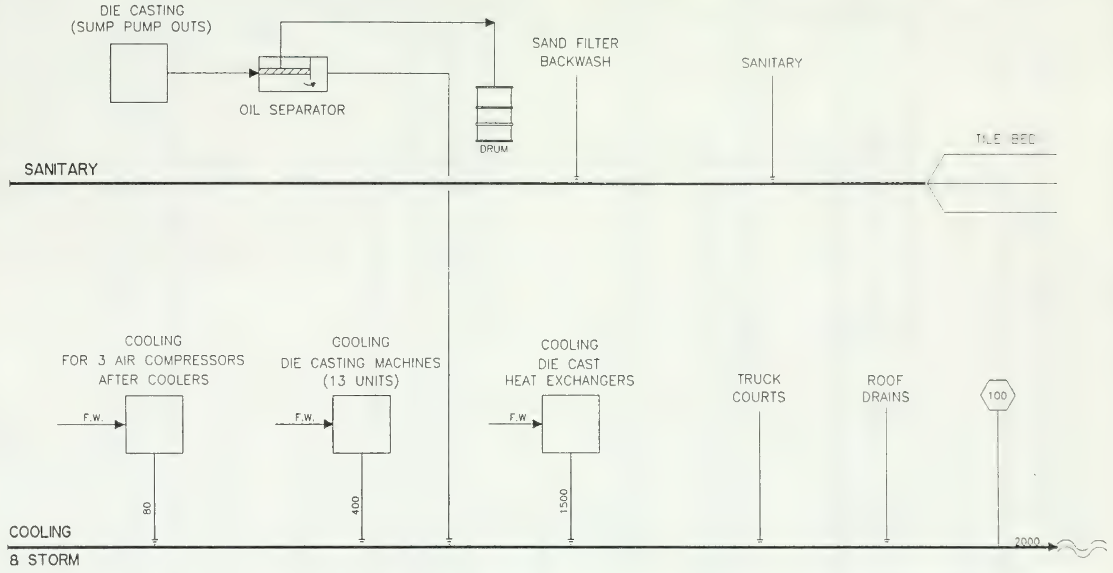
Water Use and Recycle

Plant water comes from a pump house on the of the St. Lawrence River about 400 metres distant. There is no water recirculation or reuse and almost all of the water is used for non-contact cooling as depicted on Drawing No. 289. Combined storm and cooling flows are about 2,000 m^3/d.

A small amount of the intake water is filtered and disinfected for drinking water and sanitary use.

Effluent Management

Drawing No. 289 shows that there is virtually no effluent generated at the plant after the non-contact cooling and sanitary flows have been accounted for. The sumps around the die cast machines are the only areas where water comes into direct contact with the castings and lubricants accumulating as a non-reusable waste. The total volume of liquid accumulated in the sumps is not recorded but it is estimated to be about 0.4 m^3/d. The waste is pumped from each sump using a portable pump into an oil/water separation tank. The recovered oil is decanted to a drum for disposal while the clear underflow is discharged to the cooling water sewer. The underflow is not sampled and tested but would contain any water soluble and/or biodegradable organic compounds used in the die lube formulations and possibly hydraulic fluid leaks (e.g., glycol).



FLOW m³/d
400

RICHMOND DIE
EXISTING

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-289

DATE MAY\92

Small quantities of water trapped by mist eliminators associated with the air compressors pass through another oil/water separator to remove droplets of lubrication oil that may have been entrained in the air flow.

Most of the non-contact cooling water in the plant is used for die cast machine cooling and the die cast machine heat exchangers which are used to cool the hydraulic fluid. Metal scavenging and pinhole leaks in heat exchangers can be the source of contamination of cooling water.

The plant employs several wet grinding/finishing operations but the fluids used are recirculated and topped up periodically. They are not dumped to sewer.

The cooling flow is discharged to Fraser Creek, a small creek that flows directly into the St. Lawrence River.

Contaminant Discharges

The MISA data in Table 5.6 are for the cooling water discharge to Fraser Creek. Dissolved Organic Carbon and Oil & Grease concentrations averaged 6.6 and 2.75 mg/L respectively. This is above the background concentrations in the raw water and suggest minor leakage of hydraulic fluids in one or more of the casting machine cooling systems.

5.2.7 Chrysler Canada Ltd.

Facility

Chrysler Canada's Etobicoke casting plant was built in 1942 and occupies about 11 hectares of land in the older industrial section of the community. It is an aluminum casting facility producing pistons, master break cylinders, transmission housings and other automotive products.

TABLE 5.6: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: RICHMOND DIE CASTING LIMITED - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow			
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)
Flow	N/A	12	N/A	1,980	2,232	1,674	175

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.50	11	0	6.59	31	2.3	1,120	12.7
O/G	1.0	12	7	2.75	11.0	1.0	478	5.4
TSS	5.0	12	6	11.2	88.0	2.0	2,000	22.6
Fluoride	0.10	12	0	0.13	0.20	0.07	23.0	0.26
Aluminum	0.030	12	0	0.080	0.18	0.020	14.2	0.16
Iron	0.020	12	0	0.099	0.27	0.03	17.7	0.20
Zinc	0.010	12	2	0.019	0.048	0.001	3.5	0.039
Chromium (Hexavalent)	0.010	10	5	0.014	0.073	0.0031	2.3	0.026
Toxicity	N/A	3	N/A	>100% for Rainbow Trout and *Daphnia magna*.*				

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* See Appendix 4.

Six reverberatory furnaces are used for metal melting, but most metal (approximately 75%) is delivered molten. There are twenty-seven permanent mould machines; five for master break cylinders and twenty-two for pistons. There are an additional twenty-three die casting machines and the combined pouring capacity for all of the machines is roughly 90 metric tonnes of metal per day.

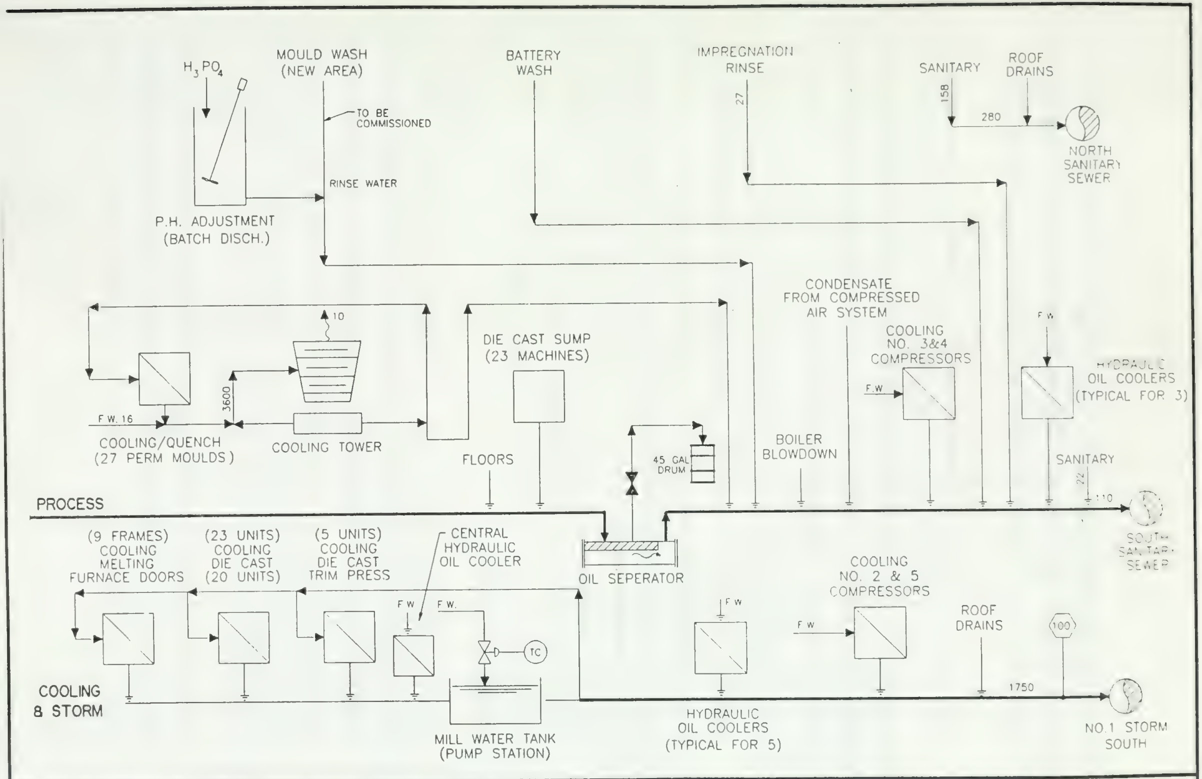
Pistons and master break cylinders are heat treated; there is a die cast trim and finishing operation; and some castings from the die cast area are made water tight by an impregnation step using a sodium silicate solution.

The plant employs about 450 people and operates twenty-four hours per day, six days a week.

Water Use and Recycle

Drawing No. 290 is a schematic flowsheet of the water use and reuse within the plant. Almost all of the water used is for cooling, boiler feedwater make-up or sanitary purposes. Small amounts of process flows originate from the die cast sumps, the impregnation rinse overflow, the battery wash station and blowdown from the permanent mould cooling/quench loop. A mould wash station was being designed at the time of the survey and this will also generate small amounts of direct contact water.

Cooling water is used for cooling the doors of the melting furnaces, air compressor cooling, die cast machine, die halves and hydraulic oil cooling, and cooling at the die cast trim presses (oil coolers). The schematic flowsheet shows a total effluent discharge from the facility a little above 2,000 m^3/d based on the flows recorded during the MISA Monitoring period. This has decreased by 15-20 percent in recent months because of water conservation measures implemented at the plant. Chrysler purchases city water at a substantial cost and there is some economic incentive to water conservation. The recent reduction in water use can be attributed to a new evaporative cooling system for the


H$_3$PO$_4$
MOULD WASH (NEW AREA)
TO BE COMMISSIONED
RINSE WATER
P.H. ADJUSTMENT (BATCH DISCH.)
BATTERY WASH
IMPREGNATION RINSE
27
SANITARY
158
ROOF DRAINS
280
NORTH SANITARY SEWER
10
3600
F.W. 16
COOLING/QUENCH (27 PERM MOULDS)
COOLING TOWER
DIE CAST SUMP (23 MACHINES)
FLOORS
45 GAL DRUM
CONDENSATE FROM COMPRESSED AIR SYSTEM
BOILER BLOWDOWN
COOLING NO. 3&4 COMPRESSORS
F.W
F W
HYDRAULIC OIL COOLERS (TYPICAL FOR 3)
SANITARY
22
110
SOUTH SANITARY SEWER
PROCESS
(9 FRAMES) COOLING MELTING FURNACE DOORS
(23 UNITS) COOLING DIE CAST (20 UNITS)
(5 UNITS) COOLING DIE CAST TRIM PRESS
CENTRAL HYDRAULIC OIL COOLER
F W
F.W.
TC
OIL SEPERATOR
COOLING NO. 2 & 5 COMPRESSORS
F W
F W
ROOF DRAINS
100
1750
NO.1 STORM SOUTH
COOLING 8 STORM
MILL WATER TANK (PUMP STATION)
HYDRAULIC OIL COOLERS (TYPICAL FOR 5)

FLOW m^3/d
110 →

CHRYSLER CANADA–ETOBICOKE
EXISTING EFFLUENT SYSTEM

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91–5070–

DATE
MAY\9

permanent mould line and a relocation of the die cast trim presses to an area which now permits some recycle of the cooling flow. This is shown schematically in Drawing No. 290.

The evaporative cooling system blows down about 6 m^3/d based on a conductivity probe with a set-point for maintaining conductivity at 900 μmho's. This represents a 2.5-3.0 fold increase in dissolved solids through evaporation as the conductivity of the city water is approximately 265 μmho's. An anti-scalant and a bactericide are added to the recycle cooling loop and are discharged through the blowdown.

Drawing No. 290 shows a partial recycle loop for the major cooling flow from the die cast machines. This system has been in place several years. The cooling water is collected in a small Mill Water Tank where a pump has been installed to recycle the flow to process cooling. Fresh water is added to the tank based on a temperature controller and any water not recycled overflows to the storm sewer. This is only a partial recycle system because, without an intermediate cooling system, a relatively large amount of fresh water is needed to keep the recirculating temperature at the target value.

Effluent Management

Effluents from the Chrysler plant discharge into two different sanitary sewers and one storm sewer. The storm sewer flow is the only one which is defined by MOE as a direct discharge and was the one subjected to MISA Regulation Monitoring. This sewer contains the large majority of the total effluent discharge from the facility but it is all cooling water overflow from the Mill Water Tank, compressor cooling water or storm runoff from some of the roof drains and parking lot. This stream receives no treatment.

The main process flows are the effluents from the die cast sumps and the blowdown from the permanent mould cooling loop. Most of this material is pumped through an oil/water separator to remove die lubricants and other immiscible organic chemicals before discharge to the South Sanitary Sewer. The permanent mould cooling loop blowdown is discharged directly to this sewer and not through the oil/water separation step. At the time of writing of this document, this stream had not been sampled and analyzed.

Contaminant Discharges

The MISA Monitoring data presented in Table 5.7 shows the quantity and quality of the non-contact cooling water as discharged to the storm sewer. The presence of significant concentrations of DOC and a small but measurable amount of Oil and Grease suggests that there was some leakage of hydraulic fluids at die casting heat exchangers similar to some of the other die cast operations. Glycol could account for the majority of the DOC which would be measurable as BOD_5 in the range of 70-100 mg/L.

Most of the metal concentrations shown in the table are slightly higher than in the city water. Metal scavenging from the metal components in the cooling systems is a logical explanation of the metal sources.

5.2.8 Western Foundry - Wingham

Facility

Western Foundry Company Limited operates a ductile iron foundry in Wingham. The plant produces exhaust manifolds for the automotive industry.

Seven induction furnaces are used for metal melting and the total melting capacity is 555 metric tonnes per day. Green sand is used for moulds and core preparation is by the cold box method with sulphur dioxide for setting the resins.

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TABLE 5.7: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: CHRYSLER CANADA (ETOBICOKE) - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m³/d)	Maximum (m³/d)	Minimum (m³/d)	Average (m³/tonne)	
Flow	N/A	12	N/A	1,480	2,104	868	21.8	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.50	12	0	35.9	45.8	10.9	763	51.9
O/G	1.0	12	6	2.08	5.9	1.0	45.6	3.1
Fluoride	0.10	12	0	0.92	1.03	0.78	20.6	1.4
Aluminum	0.030	12	0	0.12	0.20	0.028	2.8	0.19
Iron	0.020	12	0	0.067	0.12	0.010	1.5	0.10
Zinc	0.010	12	3	0.057	0.20	0.010	1.2	0.083
Cadmium	0.002	12	3	0.0057	0.024	0.0010	0.15	0.010
Copper	0.010	12	1	0.022	0.048	0.010	0.50	0.034
Lead	0.030	12	4	0.023	0.060	0.010	0.49	0.033
Nickel	0.020	12	3	0.024	0.11	0.010	0.57	0.039
Vanadium	0.030	12	5	0.039	0.090	0.020	0.75	0.051
Toxicity	N/A	2	N/A	>100% for Rainbow Trout and *Daphnia magna*.				

Western Foundry is situated within the town of Wingham occupying an irregular property 8-10 hectares in size on the north bank of the Maitland River. The plant operates twenty-four hours per day, five days per week and employs between 200 and 300 people.

Water Use and Recycle

The foundry is essentially a dry operation from the standpoint of process water use. There are no wet dust collectors nor are there any wet scrubbers for the melting furnaces. Three SO_2 scrubbers are employed in the core area but these units operate largely on recycle. Small quantities of blowdown amounting to a daily maximum of 7-8 m^3/d are discharged to the municipal sanitary sewer in periodic dumps of 0.2 m^3 at a time.

Spent regenerants from the plant de-ionization process are discharged periodically to the sanitary sewer.

The seven melting furnaces are divided among four separate glycol and water based cooling systems. Most of the heat is dissipated through recirculating glycol loops using indirect fan cooled heat exchangers. There is a water to glycol heat exchange unit on each system to assist during peak cooling loads which are generally in summer. Back-up systems exist that would automatically introduce once-through cooling with city water in the event of a mechanical failure in the glycol loop. The glycol in the system discharges with the cooling water directly to the sanitary sewer in the rare event of emergency cooling being required.

Effluent and Waste Management

The excess cooling flows and stormwater from most of the plant property exit the plant site via two storm sewers which lead to the Maitland River. The long-term average flow is about 1,300 m^3/d or roughly 4.8 m^3/t of metal melted based on recent production at the plant. These discharges receive no specific treatment.

The sanitary effluent and the minor process blowdowns from the SO_2 scrubbers and the deionization system enter the municipal sanitary sewer and are unmonitored.

Approximately 18,000 m^3/y of spent sand is disposed of in a licensed landfill on-site. The waste is a registerable, non-hazardous industrial solid waste and the landfill occupies about 1 hectare of land between the plant building and the river. Rainwater can pond within the landfill area because of the low permeability of the waste material.

Other wastes such as spent hydraulic oils and oils collected from oil/water separators associated with the air compressors are stored in an enclosed waste storage area where they await shipment for disposal.

Contaminant Discharges

Tables 5.8 and 5.9 summarize the MISA Monitoring data from the two cooling water storm sewers at Western Foundry. The average concentrations of most of the parameters in the tables were similar to concentrations present in the municipal water supply. These included fluoride, copper, and zinc in both sewers and DOC, Oil and Grease and TSS in Station 001 which is the Arthur Street Outfall. Traces of phenolics were found in both outfalls but the concentrations were below the normal provincial discharge standard of 0.02 mg/L. Slightly elevated concentrations of TSS, DOC and Oil and Grease were recorded in Station 0200 which represented about three quarters of the total discharge from the plant.

5.2.9 Canada Alloy Castings Ltd.

Facility

Canada Alloy Castings in Kitchener produces chromium and nickel alloy steel and stainless steel products including valves, pumps and general industrial machinery. It uses four

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TABLE 5.8: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: WESTERN FOUNDRY COMPANY - STATION 0100 (ARTHUR STREET OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	12	N/A	370	584	247	1.4	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	11	0	0.89	1.90	0.60	1.2	0.32
O/G	1.0	10	3	2.23	5.2	0.23	3.1	0.82
Fluoride	0.10	11	0	0.92	1.15	0.72	1.3	0.34
Aluminum	0.030	12	0	0.071	0.27	0.018	0.10	0.028
Iron	0.020	12	0	0.27	0.76	0.103	0.37	0.099
Zinc	0.010	12	0	0.043	0.23	0.0035	0.067	0.018
Copper	0.010	12	0	0.0091	0.019	0.0038	0.011	0.003
Phenolics (4AAP)	0.002	11	3	0.0069	0.015	0.0008	0.0075	0.002
Toxicity	N/A	2	N/A	>100% for Rainbow Trout and *Daphnia magna*.				

TABLE 5.9: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: WESTERN FOUNDRY COMPANY - STATION 0200 (CNR BRIDGE OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	12	N/A	921	3,650	17.4	3.4	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.50	11	2	1.22	2.7	0.50	2.7	0.72
O/G	1.0	10	5	5.47	39.4	0.23	7.9	2.1
TSS	5.0	11	7	6.53	16.0	3.6	18.0	4.8
Fluoride	0.10	11	0	0.89	1.05	0.56	2.9	0.77
Aluminum	0.030	12	0	0.18	1.24	0.008	0.21	0.057
Iron	0.020	12	0	0.73	4.0	0.076	0.71	0.19
Zinc	0.010	12	0	0.041	0.11	0.0065	0.056	0.015
Copper	0.010	12	0	0.010	0.028	0.003	0.022	0.006
Cadmium	0.002	12	8	0.0019	0.0010	0.0030	0.0075	0.002
Phenolics (4AAP)	0.002	11	6	0.0062	0.026	0.0008	0.0037	0.001
Toxicity	N/A	2	N/A	>100% for Rainbow Trout and *Daphnia magna*.				

induction furnaces with a melting capacity of about 25 metric tonnes per day. Silica sand is used in the moulding process and cores are made via an air-set/no-bake process.

The plant employs between 100 and 150 people and operates five days per week with one shift in the foundry and two shifts in the shake-out and finishing areas.

Water Use and Recycle

The production process is essentially a dry operation with negligible process water requirements. There are no wet dust collectors or furnace exhaust scrubbers. A quench tank is used for some of the production but this does not involve a continuous flow of water through the tank and the tank contents are dumped infrequently to the sanitary sewer (e.g., 45 m^3 once per week).

City water is used for cooling purposes. Most of the cooling flow is once-through cooling water used for the air compressors with the remainder (about 25%) used for make-up on closed or semi-closed loop systems. All four of the furnaces are cooled using a double loop, water based process, although only two typically are operating at any given time. The first loop recycles cooling water from the furnace through a sump and a shell and tube heat exchanger. The second loop circulates water from the shell and tube exchanger to an evaporative cooling tower and then back to a second sump. An automatic pressure filtration system operates continuously to remove suspended solids from the recycle flow with periodic backwashing governed by a timer. The backwash from the filter is discharged to the storm sewer and provides the blowdown to control dissolved solids build-up.

Canada Alloy Castings has the ability to use extra city water as make-up to the furnace/heat exchanger loop when the cooling requirement exceeds the heat exchanger capacity in the summer. This is typically not done, however. Instead, city water is run through the furnaces as once-through cooling water and discharged to the storm sewer when the closed loop system overheats.

A completely closed air cooled glycol based system was installed recently for the cooling requirements of a new holding furnace.

Effluent and Waste Management

Excess cooling water and storm runoff is discharged to a storm sewer which was the MISA Monitoring outfall. This flow is not treated and amounts 180 m^3/d or 3.3 m^3/t of metal melted based on typical production rates during the MISA Monitoring program.

The remaining sanitary effluent and occasional quench tank dumps are directed to the city sanitary sewer.

Returns (e.g., rejected castings) and waste sand containing fines, resins and catalyst from the shakeout area are stored outside. Some metal wastes are stored in dumpsters. Waste sand previously sent to a local landfill is now shipped to an asphalt company.

Contaminant Discharges

The 12-month MISA Monitoring results for the storm sewer/cooling water flow are summarized in Table 5.10. Several of the parameters were present at concentrations slightly above background levels in the city water supply including TSS, Oil and Grease, DOC and zinc.

5.2.10 Kubota Metal Corporation

Facility

Kubota Metal Corporation in Orillia employs approximately 240 people in its plant which produces steel and steel alloys for pipe and miscellaneous industrial equipment. The plant occupies a 17.6 hectare property on the outskirts of town.

TABLE 5.10: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: CANADA ALLOY CASTINGS - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m³/d)	Maximum (m³/d)	Minimum (m³/d)	Average (m³/tonne)	
Flow	N/A	12	N/A	180	250	118	3.3	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	12	0	1.50	3.20	0.60	5.2	0.28
O/G	1.0	11	4	2.62	6.56	0.23	9.8	0.53
TSS	5.0	12	9	4.3	3.6	5.0	14.3	0.77
Fluoride	0.10	12	0	0.25	0.32	0.19	0.85	0.046
Aluminum	0.030	12	2	0.041	0.074	0.0068	0.15	0.008
Iron	0.020	12	0	0.11	0.18	0.034	0.37	0.020
Zinc	0.010	12	0	0.89	10.5	0.0082	3.3	0.18
Cadmium	0.002	12	8	0.0020	0.0035	0.0010	0.007	0.0004
Copper	0.010	12	0	0.012	0.028	0.0037	0.037	0 002
Toxicity	N/A	N/A	N/A			All >100% Rainbow Trout. 1 <100% *Daphnia magna*.		

Kubota employs three electric arc and four induction furnaces with a theoretical melting capacity of 370 t/wk. Plans are underway for an expansion in melting capacity.

The plant operates on a nominal schedule comprising two shifts a day, four days per week. Operations can be extended to a seven day schedule for peak production.

There are five horizontal and two vertical centrifugal casters which produce tubes for heat exchangers among other products. There is also green sand moulding plus shell sand and cold set core production.

The plant has heat treatment facilities, a quenching operation and a sand reclaim system with a 3.6 t/h calciner as the principal component. This unit operates two to three days per week and produces sand which is suitable for partial make-up of the sand for core production. A variety of finishing and quality assurance operations such as shot blast and dye penetrant applications are employed.

Water Use and Recycle

Kubota uses very little water for process applications. All dust collection is by dry methods such as bag houses and there are no wet scrubbing or exhaust quenching units associated with the furnaces. With few exceptions water is used for cooling the furnaces. Cooling water from the furnace cooling loops and from one or two air compressors flows to a cooling pond from where a portion is recycled back to the plant. City water is available to add directly to the furnace cooling circuits if the temperature of the recycled flow from the cooling pond is too high to handle the total heat load.

All plant water with the exception of sanitary effluent, dye penetrant rinses and one or two minor sources ends up in the Cooling Pond. This includes small volumes of water from the quenching operation and mould wash water. A small amount of water is evaporated in the sand cooler which follows the sand reclaimer. The pond surface is the only other area

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where a significant amount of evaporative cooling is possible. The pond also collects storm runoff from a portion of the property. It is suspected that there is a constant infiltration of groundwater as the pond overflows continuously even when the foundry is not operating.

It is difficult to complete an accurate water balance due to the conditions cited above. Nevertheless, it is known that the net average discharge from the pond during the MISA Monitoring program was 360 m^3/d or about 12.9 m^3/t of metal melted.

Effluent and Waste Management

There is no specific effluent treatment process at Kubota besides natural settling or biodegradation that may occur in the Cooling Pond. The mould wash water may contain a suspension of silicon dioxide and the quench tank water could contain metals and possibly traces of organic compounds.

Plant staff report that the recycle water from the pond can cause fouling problems from time to time in the heat exchange units of the furnace cooling systems. This could be, in part, due to biological growth within the pond.

Approximately 1,000 t/y of sand is disposed of annually at a local landfill whereas 4,000 t/y is reclaimed.

Contaminant Discharges

Table 5.11 summarizes the MISA Monitoring data for the Cooling Pond outfall. The average TSS concentration was 26 mg/L, possibly owing to algae growth in the pond. The data also show small but elevated concentrations of DOC, Oil and Grease, ammonia and nitrite plus nitrate. Some of the metals were above the background concentrations in the city water supply and phenolics were detected but were almost always below the provincial discharge standard of 0.02 mg/L.

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TABLE 5.11: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: KUBOTA - FAHRAMET DIVISION - STATION 0100 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	12	N/A	360	820	135	2.8	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.50	12	0	5.19	8.80	1.0	61	1.7
O/G	1.0	12	5	3.03	12.6	1.0	54	1.5
TSS	5.0	12	0	25.7	35.0	17.0	320	8.8
(NO_2+NO_3)-N	0.25	4	0	0.67	0.78	0.50	6.4	0.18
(NH_3+NH_4)-N	0.25	4	0	1.37	2.3	0.68	12	0.34
Total P	0.10	4	1	0.097	0.14	0.030	0.9	0.025
Total Cyanide	0.005	4	1	0.009	0.012	0.005	0.1	0.003
Fluoride	0.10	12	2	0.16	0.28	0.10	1.9	0.052
Aluminum	0.030	12	0	0.41	2.61	0.040	3.9	0.11
Iron	0.020	12	0	0.17	0.59	0.030	1.8	0.049
Zinc	0.010	12	4	0.016	0.065	0.004	0.2	0.005
Copper	0.010	12	4	0.018	0.052	0.003	0.2	0.005
Phenolics (4AAP)	0.002	12	4	0.007	0.026	0.002	0.07	0.002
Toxicity	N/A	4	N/A	>100% for Rainbow Trout and *Daphnia magna*.				

The LC_{50} values from the rainbow trout and *Daphnia magna* bioassays were all greater than 100 percent indicating a non-toxic effluent.

5.2.11 Haley Industries

Facility

Haley Industries (Haley) operates a magnesium and aluminum casting and finishing plant for products such as gear boxes and engine parts for the aerospace industry. The plant is located on a fenced plant site of 3.0-3.5 hectares near Renfrew and has been operating at this location since the mid 1950's. The total plant property comprises 16 hectares and includes a company operated landfill adjacent to the main plant.

Production at Haley is about 35 percent magnesium based and 65 percent aluminum with magnesium supplied by a neighbouring magnesium mining and smelting facility. Oil and electrically heated crucibles are used for metal melting and the melting capacity was about 5.5 metric tonnes per day at the time of site visits associated with this study. A modest expansion was underway which will increase melting capacity by about 0.6 t/d.

Silica sand is used for moulding and cores are prepared from silica or zircon sand. Both furan and sulphur dioxide processes are used in the core and mould setting operations. There are seven sulphur dioxide scrubbers. A thermal sand reclamation system adds to conventional sand recycling to optimize the reuse of the silica sand. New sand is used for cores.

Finishing operations include shot blast, sanding, grinding, fettling and heat treatment. There are also chemical pickling, etching and cleaning operations which use hydrofluoric/nitric, chromic and sulphuric acid baths and rinses.

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Among the many quality control and quality assurance steps in the manufacturing process are X-ray examinations, pressure testing and fluorescent dye penetrant applications.

Haley Industries operates one to two shifts per day depending on the department in a normal five day week.

Water Use and Recycle

Water supply for Haley is provided by the adjacent mining operation and the total daily water use is relatively small at about 130 m^3/d. Water use at the plant does not follow the same pattern as for the other casting plants described previously. The crucible melting techniques do not require cooling water for heat dissipation unlike most of the other metal melting processes already discussed. The plant operates several wet dust collectors with intermittent blowdown from cleaning operations.

There is a non-contact cooling flow for the heat exchanger for the compressed air system that could contribute 5-10 m^3/d to the total flow.

The sanitary effluent at Haley is treated and monitored on site as the plant has no access to a municipal sanitary service. The water balance shown in Drawing No. 291 shows that this alone accounts for forty percent of the total effluent discharge at the plant.

Process Effluent Sources

There are numerous sources of process effluents, many of which are intermittent batch discharges. Following is a list of several of the most important sources:

- rinses from the silver recovery unit of the X-ray processing system (contains silver, acetate, NH_4-N, chelating agents);

- rinses from dye penetrant test areas (contains organic carriers and solvents/BOD_5);

- sulphur dioxide scrubber blowdowns (contains suphites, DOC, cyanide, nitrates, high dissolved solids, fluoride, phenolics, aluminum and other metals);

- dust collector blowdowns (contains TSS, fluoride, zinc, and nitrate); and

- various neutralized rinses and dragouts from the chemical etching, pickling and cleaning steps (contains fluoride, nitrates, chromium, trace organics and metals).

Effluent and Waste Management

The sanitary and process effluents combine into one discharge which enters McLaren Creek flowing to the Ottawa River. The storm sewer discharges separately into the Creek.

Sanitary effluent receives treatment in a package extended aeration biological treatment process. The BOD_5 containing dye penetrant rinse waters are also sent to this system.

Drawing No. 291 shows the basic treatment units for the process effluents as they existed during the MISA Monitoring program. The chromic acid dragout is treated with sodium metabisulphite to reduce hexavelant chromium to trivalent chromium. This is then neutralized to pH 7 using lime to precipitate metal sludges before discharge.

The hydrofluoric/nitric acid dragout is also treated with lime to pH 7 for the same purpose.

Dilute acid rinses are collected and neutralized with caustic soda before discharge.

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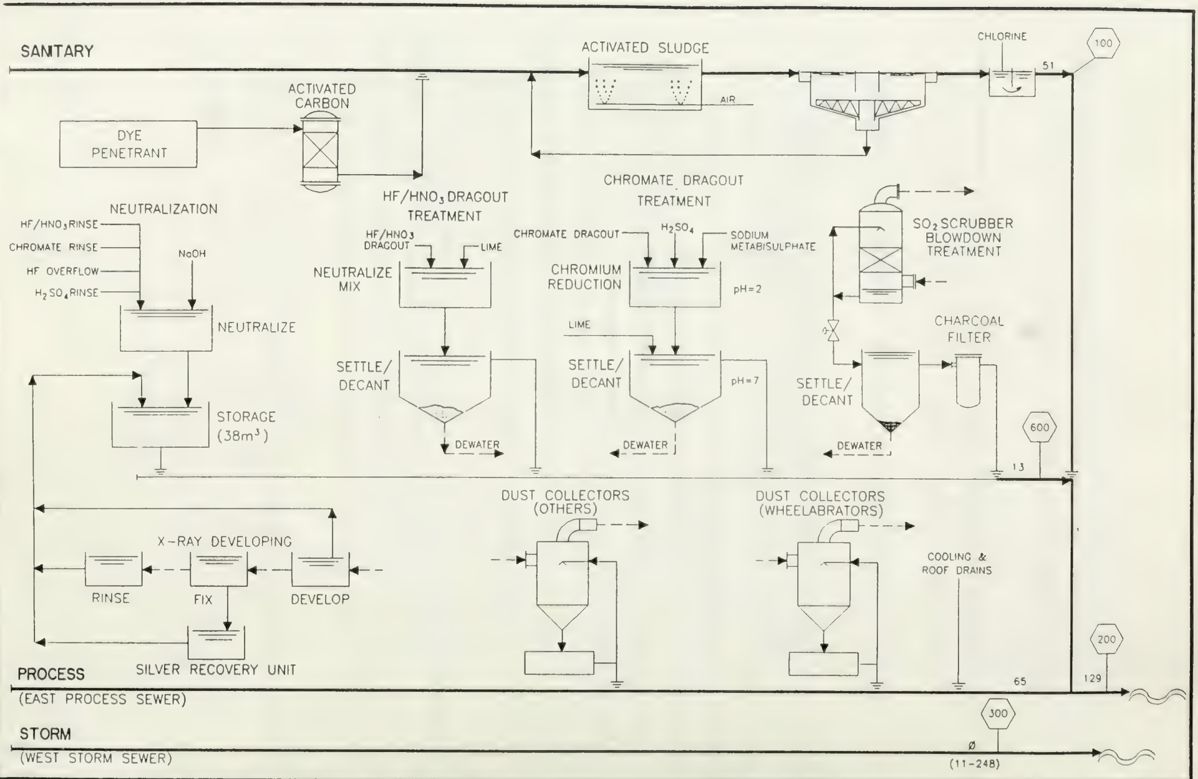

FLOW m^3/d
65

HALEY INDUSTRIES LIMITED
EXISTING
(DURING MISA MONITORING)

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-291

DATE MAY 92

An electrolytic plating process is used to recover some of the silver in the spent fixer used in the X-Ray developing operation. The effluent from this unit and the rinse overflows then proceed indirectly to the process sewer.

Blowdowns from the sulphur dioxide scrubbers are collected in a batch tank to allow suspended solids to settle and the contents are discharged to the process sewer through a carbon filter which is intended to remove traces of organic compounds.

Blowdowns from the several dust collectors are sent without treatment to the East Process Sewer.

Haley Industries has been working on upgrading the total effluent management system during the last several years as the plant has been unable to meet all limits currently specified in their Certificate of Approval. Drawing No. 292 shows schematically the modified treatment process as it is planned following completion of a Phase 1 upgrade in progress at the time of this study. A Phase 2 has been discussed but it is BEAK's understanding that no commitments have been made beyond Phase 1.

Following are several of the major improvements associated with the upgraded facility:

1. The dust collector blowdowns will be collected and treated with lime for metals and suspended solids removal.

2. General improvements are to be made in effluent segregation and pH adjustment to improve overall metal removal.

3. A carbon dioxide neutralization system to make a final pH adjustment after lime treatment (CO_2 replaces need for sulphuric acid which adds sulphate and total dissolved solids to the flow).

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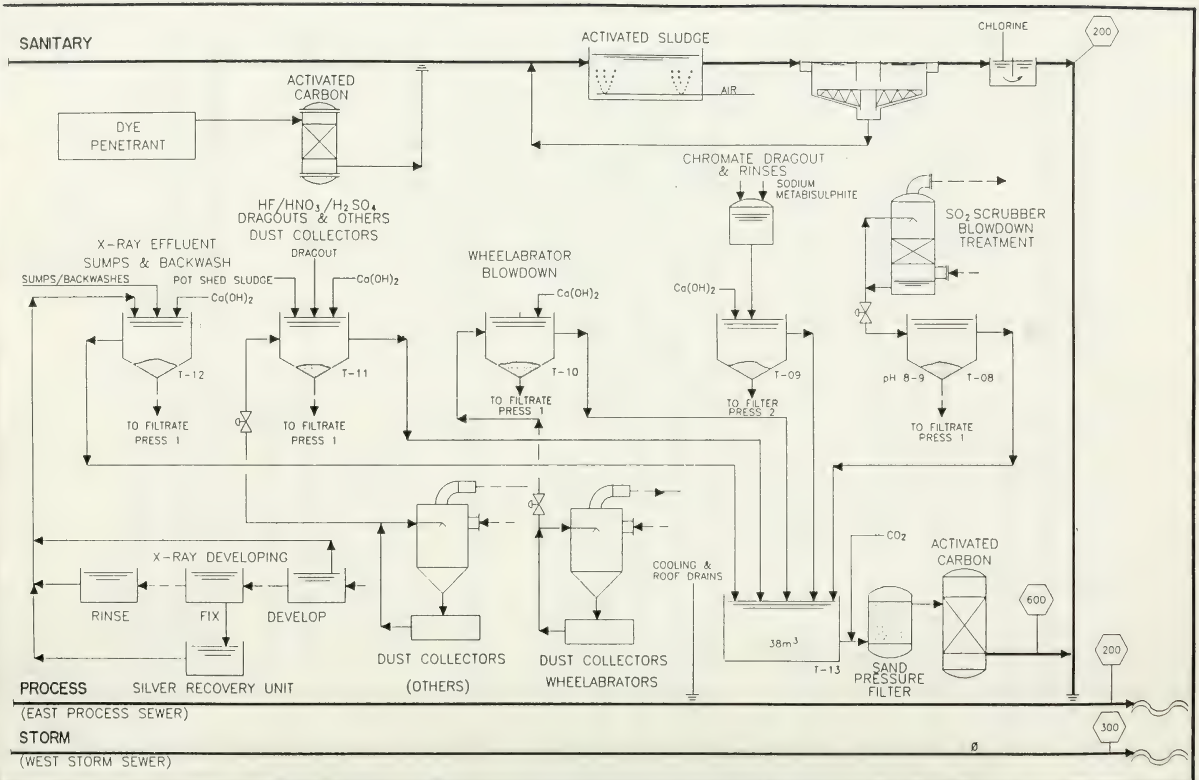

FLOW m³/d 0	HALEY INDUSTRIES LIMITED EXISTING	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO 91-5070-292 DATE MAY\92

4. A pressure sand filter will be used to remove residual suspended solids in the treated, decanted process flows.

5. The total process flow will be treated in a carbon column to remove trace concentrations of phenolics and several other organic compounds.

The collection and disposal of solid wastes includes the following.

- dewater, drum and separate contract disposal of chromate sludge;
- casting sand disposal to plant operated landfill at approximately 2,000 tonnes per year;
- dewatered sludges from all process lime treatments and SO_2 scrubber blowdowns except chromate sludge disposed of in plant operated landfill; and
- waste oils are collected and reused by employees.

Contaminant Discharges

Tables 5.12 through 5.14 present data summaries from the MISA Monitoring period for the treated sanitary effluent, the combined final effluent and the storm sewer, respectively.

The storm sewer data indicate significant concentrations of several contaminants such as fluoride, ammonia-N, TSS and DOC.

The combined final effluent contains relatively high concentrations of TSS, fluoride, nitrate, ammonia, total cyanide, and several metals including silver. The DOC concentration of 36 mg/L also suggests a substantial amount of BOD_5 may remain in the effluent. Many of

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TABLE 5.12: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: HALEY INDUSTRIES - STATION 0100 (SANITARY)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	255	N/A	51.5	89.8	11.5	13.7	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	53	0	16.0	76.0	7.12	245	0.92
O/G	1.0	154	112	1.38	29.5	0.3	18.7	0.07
TSS	5.0	253	3	93.3	2,026	1.0	1,230	4.6
(NH_3+NH_4)-N	0.25	155	62	5.33	32.6	0.22	69.3	0.26
Total P	0.10	52	1	2.02	10.0	0.10	29.3	0.11
Bis(2-ethylhexyl)phthalate	0.0022	4	0	0.026	0.043	0.011	0.53	0.002

TABLE 5.13: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: HALEY INDUSTRIES - STATION 0200 (COMBINED FINAL OUTFALL)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	365	N/A	129	440	20.0	48.2	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	52	0	36.1	124	8.9	2,310	6.2
O/G	1.0	156	68	1.58	11.1	0.10	82.1	0.22
TSS	5.0	361	1	307	2,496	3.0	15,680	42.0
(NO_2+NO_3)-N	0.25	52	5	28.6	146	0.025	1,530	4.1
(NH_3+NH_4)-N	0.25	158	3	32.2	96.5	0.22	1,750	4.7
Total P	0.1	51	0	1.99	52.0	0.10	131	0.35
Total Cyanide	0.005	12	0	1.01	2.0	0.29	74.7	0.20
Fluoride	0.10	155	0	30.2	116	0.58	1,680	4.5
Aluminum	0.030	155	0	2.16	25.4	0.10	127	0.34
Iron	0.020	155	0	408	26,190	0.16	20,000	53.5
Zinc	0.010	155	0	0.85	12.71	0.030	48.5	0.13
Cadmium	0.002	155	57	0.0059	0.038	0.0018	0.37	0.001
Copper	0.010	155	1	0.625	4.60	0.009	33.6	0.090
Lead	0.030	155	44	0.064	0.40	0.015	3.4	0.009
Nickel	0.020	155	81	0.050	0.87	0.020	2.6	0.007
Molybdenum	0.020	154	99	0.028	0.14	0.018	1.5	0.004
Silver	0.030	155	15	0.40	1.93	0.010	21.3	0.057
Phenolics (4AAP)	0.002	360	168	0.044	0.57	0.002	1.5	0.004
Bis(2-ethylhexyl)phthalate	0.0022	12	2	0.0075	0.018	0.0004	0.37	0.001
Toxicity	N/A	12	N/A			1/10 >100% Rainbow Trout.* 3/6 >100% *Daphnia magna*.*		

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* See Appendix 4.

TABLE 5.14: SUMMARY OF FINAL TREATED EFFLUENT

PLANT: HALEY INDUSTRIES - STATION 0300 (STORM)
SAMPLING PERIOD: 01 MAY 1990 - 30 APRIL 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	
Flow	N/A	12	N/A	107	248	10.9	28.5	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
DOC	0.5	12	0	7.79	34.7	2.1	232	0.87
TSS	5.0	12	0	179	806	8.0	6,000	22.5
(NO_2+NO_3)-N	0.25	12	0	2.34	11.8	0.65	72	0.27
(NH_3+NH_4)-N	0.25	12	3	24.4	253	0.20	800	3.0
Total P	0.1	12	6	0.14	0.38	0.090	3.5	0.013
Total Cyanide	0.005	12	6	0.39	4.53	0.005	12.8	0.048
Fluoride	0.10	12	1	8.97	37.0	0.030	293	1.1
Aluminum	0.030	12	1	1.65	10.2	0.030	48	0.18
Iron	0.020	12	0	150	1,770	0.29	6,830	25.6
Zinc	0.010	12	1	0.31	0.86	0.009	6.1	0.023
Copper	0.010	12	3	0.021	0.070	0.009	0.53	0.002
Lead	0.030	12	6	0.045	0.15	0.015	1.6	0.006
Phenolics (4AAP)	0.002	12	3	0.043	0.28	0.0002	1.3	0.005

these are still well above limits set in the existing MOE Certificate of Approval although the present Phase 1 treatment plant upgrade will produce a measurable improvement.

The MISA Monitoring showed that the effluent is acutely lethal to rainbow trout and *Daphnia magna*. The concentration of ammonia-N was 32 mg/L and this alone could account for much of the observed toxicity.

5.3 Sub-Sector Grouping of Ontario Plants

Table 5.15 summarizes selected process and effluent data for each of the nine direct discharging plants as well as for the additional Ontario plants visited during the study. There are several features that distinguish the top four (e.g., General Motors, Ford, Crowe and Canada Pipe) from all the others. Ford and General Motors are the two of particular interest.

Both plants use large volumes of process water for dust collection, furnace exhaust scrubbing and slag quenching whereas the remaining 7 plants have practically no process water applications of this type. The total water usage at Ford and General Motors is one to two orders of magnitude greater than at any of the other plants. These are also by far the two largest producers within the sector.

The control technologies applicable to reducing contaminant discharge at Ford and General Motors are substantially different from the remaining casters as will be seen in the section describing the BAT candidate plants.

It is reasonable to create a Wet Processing Sub-sector for purposes of the BAT review based on the preceding discussion.

Haley Industries is a unique operation not comparable to any of the other metal casting plants. It is unique because the nature of the process effluent produced at Haley and the

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type of applicable treatment processes are heavily influenced by spent acid rinses from chemical treatment operations not used elsewhere. The wastes are derived from chromic, nitric, sulphuric, and hydrofluoric acid use. The contribution of spent X-ray developing solutions contributes biologically degradable organics and silver to the effluent in quantities sufficient to demand special treatment.

Haley Industries is considered as a sub-sector by itself for the purpose of completing a practical BAT review. It is recognized that the MOE Issues Resolution Report recommended that sub-sectors be restricted to a minimum of two plants. This is not practical under the circumstances.

The remaining six casting plants in Table 5.15 comprise three aluminum die casters and three ferrous based foundries. These plants are not sufficiently different in their use of water to justify a further sub-categorization. Most of the effluent discharges at all of these plants are from non-contact cooling sources. Contaminated process effluents are either non-existent or very small in volume. Oil and suspended solids removal are common issues for the process effluents that are generated in this group.

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TABLE 5.15: SUB-SECTORS FOR ONTARIO CASTING PLANTS

Plant	Metal	Casting	Total Direct (m^3/t)	Total Final Effluent (m^3/d)	Wet Processes			
					Dust Collectors	Furnace Scrubbers	Slag Quench	Chemical Milling
Wet Processing Sub-Sector								
Ford	Grey/Nodular	Sand	114	73,600	Yes	Yes	Yes	No
General Motors	Grey/Nodular	Sand	90	136,000	Yes	Yes	Yes	No
Crowe	Grey Iron	Sand	*	*	No	Yes	No	No
Canada Pipe	Grey/Nodular	Sand, Centrifugal and Continuous	*	*	No	Yes	No	No
Dry Processing Sub-Sector								
Franklin	Aluminum	Die Cast	640	280	No	No	No	No
Richmond	Aluminum	Die Cast	175	1,980	No	No	No	No
Chrysler	Aluminum	Die Cast and Permanent	22	1,480	No	No	No	No
Western Foundry	Grey/Ductile	Sand	4.8	1,290	No	No	No	No
Canada Alloy	Stainless Steel	Sand	3.3	180	No	No	No	No
Kubota	Steel	Sand and Centrifugal	12.9	360	No	No	No	No
Haley Industries	Magnesium and Aluminum	Sand	48	130	Yes	No	No	Yes

* Unavailable - Discharge to sanitary sewers only.

6.0 SELECTED WORLD-WIDE CASTING OPERATIONS

6.1 Wet Processing Sub-Sector

6.1.1 Foundry No. 1

Facility

Foundry No. 1 is situated on 216 hectares of land and has been operating since 1919. The product is grey iron for automotive parts. A nodular iron plant is also on the property but was closed permanently in 1987.

The property contains outside stockpile areas for by-products such as spent casting sand, a significant area for basins and lagoons associated with the wastewater and stormwater facilities, and a 35 hectare engineered landfill site.

Five cupolas have a theoretical melting capacity of 5,200 metric tonnes of metal per twenty-four hour day. Green sand moulding techniques are used and core making employs both hot box and cold box methods.

Water Use and Recycle

The foundry uses process water for cupola exhaust quenching and scrubbing, slag quenching and for dust collection and grinding scrubbers.

Drawing No. 293 presents a water use and effluent treatment schematic of the facility. Virtually all of the 92,500 m^3/d of process water is recycled after the suspended solids removal steps. This comprises the use of two circular classifiers or high rate clarifiers to remove sand from the scrubbing effluents followed by triple super phosphate (TSP) and

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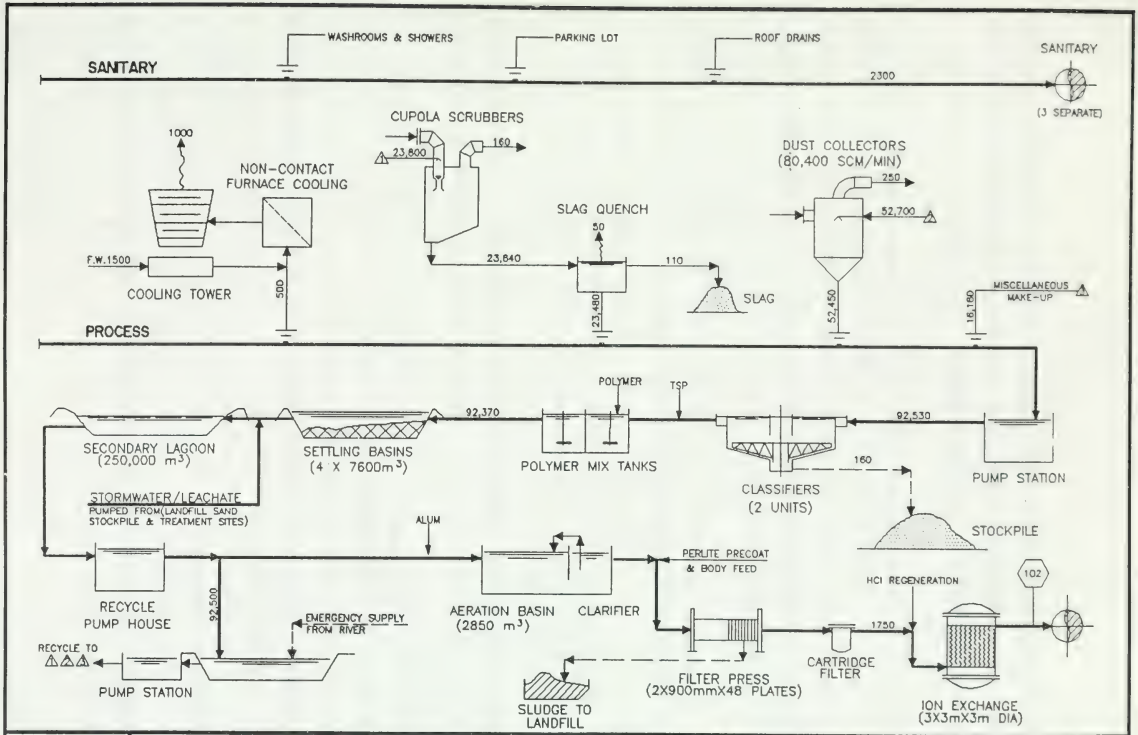

FLOW m³/d 1750 →	FOUNDRY NO.1	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO. 91-5070-293 DATE OCT\92

polymer addition ahead of four settling basins for fines removal. The TSP helps to tie up metals in the sludge (e.g., non-leachable) so the sludge is not listed as a hazardous waste according to the EPA system of classification.

The TSP is a calcium based phosphate and has been effective in limiting the build-up of hardness in the recycled process water loop. Water hardness in the process effluent prior to 1988 when the recycle system was implemented was 200-240 mg/L. This increased gradually to 430 mg/L during the first six months after recycle was introduced and before TSP dosing commenced at a rate currently about 680 metric tonnes per year of 85 percent $Ca (H_2PO_4)\bullet 2 H_2O$ (e.g., about 30 mg/L TSP dosing to the recycle flow). The hardness has declined to roughly 270 mg/L at this time. There has been no report of scaling or fouling problems associated with the recycle system.

A deionizing system was installed to treat city water make-up into the plant at the time of the recycle project to prevent hardness build-up. This system has not been needed.

The city water make-up comprises approximately 3,800 m^3/d for sanitary uses and to account for evaporative losses. Non-contact cooling water from the cupola area and other significant cooling flows are collected, cooled in a large evaporative cooling tower and recirculated. Small volumes of cooling tower blowdown are discharged to the general sewer along with the scrubber flows and enter the process recycle loop.

The pumping station which formerly provided river water for process water requirements is maintained as a back-up water supply.

Wastewater Management

Sanitary effluent along with some stormwater from roof drains and parking areas is discharged to the city sanitary sewer.

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Stormwater from much of the property including the stockpile areas and the landfill site is pumped or flows by gravity into a 10 hectare by 250,000 m^3 volume Secondary Lagoon downstream of the settling basins (Drawing No. 293). The process effluent recycle pumping station pumps water from this lagoon at a rate to suit the plant needs and the inventory of liquid in the lagoon is allowed to increase or decrease within limits. This provides surge capacity for storm events.

A small daily flow of "blowdown" from the recycle is processed through the effluent treatment system with the flow rate adjusted as needed to maintain the proper water inventory in the Secondary Lagoon.

Drawing No. 293 shows that effluent treatment for the blowdown comprises an activated sludge system with pressure filtration of the final clarified effluent. This is followed by an ion exchange process utilizing a special resin supplied by Rohm & Haas (e.g., IRC 718) which is designed for selective removal of bivalent metal ions such as copper, lead, zinc, cadmium and silver, but excluding calcium and magnesium. A cartridge filter arrangement precedes the ion exchange process as a back-up to prevent suspended solids from permanently fouling the resin.

Alum is added to the flow entering the activated system to help remove the phosphorus present in the process water loop. The dosing rate is approximately 120 mg/L as aluminum sulphate hydrate. This provides the solids bulk needed to permit a proper concentration/ inventory of mixed liquor suspended solids to be maintained in the aeration basin. The concentration of biodegradable organic matter measured as BOD_5 entering with the blowdown is too low to permit biosolids growth alone to provide the solids mass needed for this purpose. The BOD_5 concentration into the system varies between 8 and 45 mg/L with an average of 23 mg/L based on a very few measurements. A municipal wastewater of this organic strength could not support an activated sludge process because of the low solids yield.

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The activated sludge process at Foundry No. 1 was operating well when visited. The final clarifier supernatant was clear and a healthy concentration of mixed liquor suspended solids was present (e.g., 2,000-2,500 mg/L). BEAK was informed that the overall process had functioned much better following the start of TSP dosing to the process effluent and the subsequent increase in alum dosing at the treatment plant needed to accommodate the higher phosphorus concentrations.

The small amount of waste activated sludge that requires disposal is pumped into the process effluent upstream of the settling basins where it is removed with the primary sludge.

Staffing for the wastewater operations includes a total of fifty-three person-shifts per week. This comprises three operators per shift times three shifts a day during the weekdays; cut back to two people and two shifts on weekends. There is one laboratory technician and the area manager.

Total annual operating cost for 1990 including chemicals, labour and disposal was \$2.9 million.

Contaminant Discharge

Table 6.1 summarizes the final effluent quality from Foundry No. 1. The average daily flow is approximately 1,000 m^3/d and represents about 1 cubic metre per metric tonne of metal melted.

The concentrations of most contaminants in the table are at or below MOE's RMDL values including phenolics and total cyanide which average 0.002 mg/L and 0.004 mg/L respectively.

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TABLE 6.1: SUMMARY OF FINAL TREATED EFFLUENT - FOUNDRY NO. 1 - OUTFALL 102 (FINAL OUTFALL)
SAMPLING PERIOD: 10 APRIL 1991 - 20 APRIL 1991 and 13 AUGUST 1991 - 21 AUGUST 1991 (OCTOBER 1990 - SEPTEMBER 1991 FOR FLOW)

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	365	N/A	1,110	2,310	255	0.98	1.64:1
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
BOD_5	5.0	12	12	0.5	<3.0	<2.0	0.58	0.65
TSS	5.0	12	11	0.88	5.0	<4.0	0.99	1.12
O/G	1.0	12	12	0.10	<5.0	<5.0	0.12	0.13
Phenolics (4AAP)	0.002	12	7	0.002	0.006	<0.002	0.0027	0.003
pH	N/A	N/A	N/A	7.42	7.67	N/A	N/A	N/A
Total P	0.10	12	0	0.99	1.7	0.37	1.17	1.32
NH_3-N*	0.25	68	62	0.16	0.50	<0.1	0.16	0.18
Aluminum	0.030	2	0	0.003	0.10	0.05	0.003	0.0033
Cadmium	0.002	2	0	0.001	<0.01	<0.01	0.001	0.0011
Copper	0.010	12	6	0.001	<0.02	<0.01	0.00089	0.001
Nickel	0.020	2	1	0.002	<0.05	<0.02	0.002	0.0022
Zinc	0.010	12	0	0.059	0.10	0.03	0.070	0.079
Iron	0.020	2	0	0.025	0.03	0.02	0.025	0.028
Lead	0.030	12	0	0.003	<0.08	<0.05	0.0035	0.004
Chromium	0.020	12	6	0.002	<0.04	<0.02	0.0027	0.003
Chromium (Hexavalent)	0.010	2	0	0.01	<0.05	<0.04	0.001	0.0011
Silver	0.030	12	6	0.003	<0.050	<0.020	0.0035	0.004
Chloroform	0.010	12	12	N/A	<0.010	<0.010	N/A	0.000
Methylene Chloride	0.010	12	12	N/A	<0.010	<0.010	N/A	0.000
Cyanide	0.005	13	11	0.004	0.008	0.0022	0.0035	0.004

Notes * Data for March 1991 through October 1991 (excludes cold weather data).
** Average is not LTA since only two data points available.

(Rev. 19 Oct. 1992)

The ammonia concentration in Table 6.1 is the average for the period March 1991 through October 1991 when the treatment system was producing a completely nitrified effluent. Ammonia concentrations were higher in the winter as the operating temperature is very low and nitrification is incomplete. Blowdown temperatures drop to 3-5 degrees C and this would drop further during the twenty-four hour retention in the aeration basin. It is difficult to maintain nitrifying conditions at such low temperatures. Heat loss and evaporation from the large Secondary Lagoon with its shallow depth and large surface area is the primary reason for the low temperature. The process effluent is warm to hot as it exits the scrubbing and dust collecting systems.

6.1.2 Foundry No. 2

Facility

Foundry No. 2 is an aluminum casting plant that can melt a maximum of 680 metric tonnes of metal per day to produce pistons, transmission cases and engine blocks. The plant building occupies 8.5 hectares on a 56 hectare site.

Five active and three back-up induction furnaces and seventeen reverberatory furnaces provide the molten aluminum for the die casting and permanent mould operations. Metal melting occurs in conjunction with plant operation which is typically scheduled for five days per week, twenty-four hours per day. The plant has worked weekends as production requires.

Water Use and Recycle

Foundry No. 2 uses a combination of stormwater and city water as make-up to the process water recycle system. Process water uses include a wet scrubbing system for the induction furnaces, casting quench, mould cooling, additional treatment for corrosion protection and die casting operations. Approximately 7,800 m^3/d of treated effluent are recycled for

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cooling and process uses compared to only 990 m^3/d of city water make-up to accommodate sanitary requirements, evaporative losses and final effluent blowdown.

Effluent Management

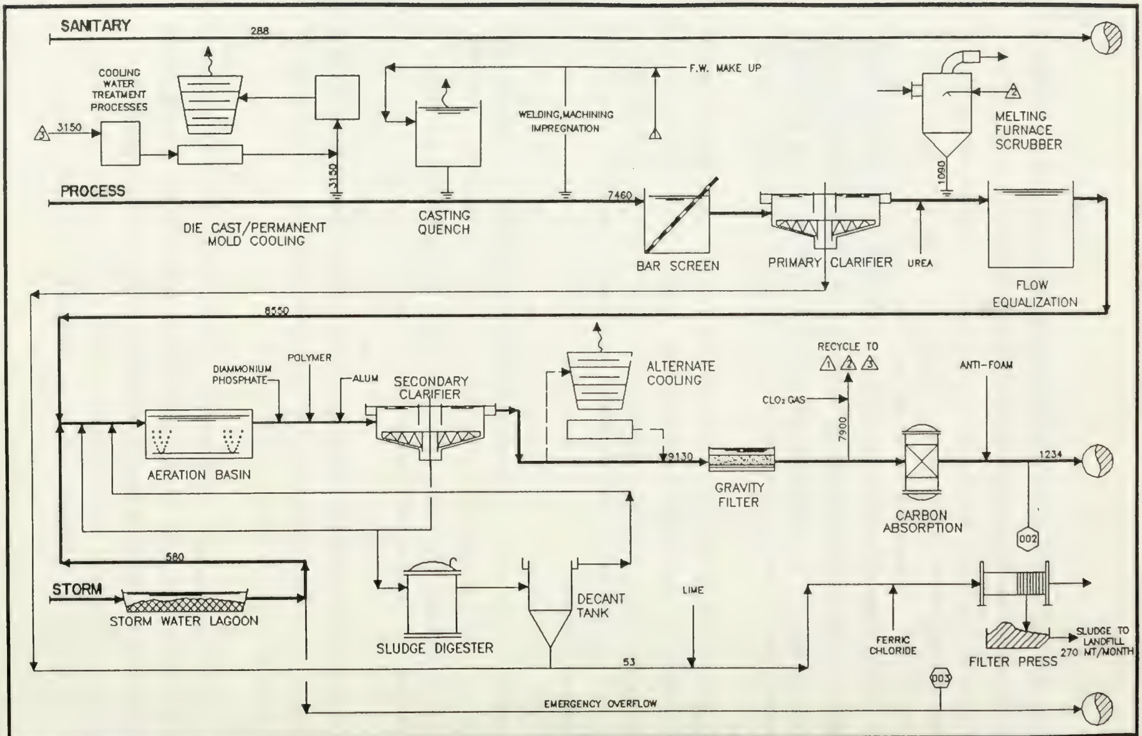
The effluent treatment process at Foundry No. 2 is very similar to the system at Foundry No. 1. Suspended solids and floating scum/oil in the process effluent are removed via two primary clarifiers. This is followed by a flow equalization basin which also receives melting scrubber blowdown which is relatively low in suspended solids (Drawing No. 294).

Equalized process effluent with a BOD_5 of about 75 mg/L and a bleed from a stormwater basin enter an activated sludge biological treatment system. Diammonium phosphate and urea are added to supply nitrogen and phosphorus nutrient requirements. Alum and polymer are also reported added to the final clarification step to help with solids removal and residual phosphorus removal.

Gravity filters are used for suspended solids polishing following the activated sludge process. It is at this point that the majority of the flow is recycled back to the plant. Recycle at Foundry No. 2 occurs following activated sludge treatment as compared to Foundry No. 1 where recycle is ahead of biological treatment.

A cooling tower is available to keep temperature of the recycle flow within specifications required at the various cooling and scrubbing processes in the plant. However, this tower is not in use at this site as it has not been needed.

Activated carbon adsorption is the final effluent treatment step before the 1,200 m^3/d of flow is discharged. This is the only significant treatment step that differs from the process described for Foundry No. 1 where ion exchange is the final treatment process.



FLOW m³/d
1234 →

FOUNDRY NO.2

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO.
91-5070-294

DATE OCT\92

Sanitary effluent is collected and discharged to the municipal sanitary system.

Contaminant Discharges

Final effluent data are from Foundry No. 2 are presented in Table 6.2. The average BOD_5 and phenolics concentrations are at or below the RMDLs which suggest that all biodegradable contaminants that may have been present in the process effluent have been removed. Most of the phenolics concentration data for the effluent downstream of activated sludge but upstream of the carbon columns were below the local method detection limit of 0.02 mg/L. It is therefore not possible to determine whether the carbon columns had any effect on effluent quality.

6.1.3 Waupaca Foundry - Waupaca, WI

Facility

Waupaca Foundry is one of the largest grey and ductile iron foundry in the USA. Plant No.'s 2 and 3 produce grey iron castings with a wide range of products for the transportation industry, agricultural machinery and construction equipment. Valves, pump casings, and compressor housings are also produced.

These plants were constructed in 1965 and 1969 and have one cupola with a melting capacity of 1,740 metric tonnes per day. Disamatics mould machines are used and cores are prepared via both warmbox and sulphur dioxide curing processes.

Water Use and Recycle

Water supply is from wells which are also the city water source. Process water is used for slag quenching, cupola exhaust quenching and scrubbing and for a few wet dust collectors.

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TABLE 6.2: SUMMARY OF FINAL TREATED EFFLUENT - FOUNDRY NO. 2 - STATION 002 (FINAL OUTFALL)
SAMPLING PERIOD: SEPTEMBER 1990 - AUGUST 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	365	N/A	1,234	N/A	N/A	3.81	N/A
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
BOD_5	5.0	144	28	3.5	29	<1.0	13.3	4.3
pH	N/A	49	0	7.0	7.85	6.5	N/A	N/A
TSS	5.0	53	46	2.21	11.0	<1.0	8.4	2.7
O/G	1.0	97	0	1.2	13.0	<5.0	4.6	1.5
Phenolics (4AAP)	0.002	150	0	0.002	0.10	<0.02	0.0076	0.0025
NH_3-N	0.25	52	42	0.19	1.5	<0.02	0.72	0.23
Copper	0.010	41	36	0.005	0.02	<0.002	0.0.19	0.0062
Lead	0.020	41	37	0.009	0.04	<0.005	0.034	0.011
Zinc	0.010	42	0	0.14	0.24	0.064	0.53	0.17
Magnesium	0.050	41	0	17.4	45	7.6	73.9	23.9
Calcium	0.050	42	0	126	250	53	480	155
PCB	0.0001	20	18	N/A	0.00034	<0.0001	N/A	N/A

N/A - Not available

At Waupaca the process flows and cooling flows are segregated. The process effluent is collected, treated with lime to increase pH from 6.5 to 7.5, flocculated and then settled in three rectangular clarifiers. At this point approximately 3,100 m^3/d is recycled back to the process and a small bleed flow of 200 m^3/d is directed to the wastewater treatment system.

Clarifier sludge is thickened with lime and cement and then dewatered using filter presses. Drawing No. 295 is a schematic flowsheet of the water recycle and effluent treatment system for Plant No. 2 and No. 3.

Effluent Management

The blowdown from the recycle process flow contains concentrations of phenolics from 10-40 mg/L and total cyanides from 5-15 mg/L. This is high compared to most other similar casting effluents. A relatively complex multi-stage treatment process has evolved in order to meet EPA's stringent requirements for these parameters.

The blowdown is treated to two successive oxidation steps to destroy phenolics and cyanide. The first step uses chlorine dioxide for cyanide oxidation and the second step uses lime and potassium permanganate for phenol oxidation at pH 11. This is followed by polymer addition, mechanical flocculation and settling in a lamella type clarifier. The treatment process can be followed by examining Drawing No. 295.

Clarifier effluent enters an agitated tank to which about 22 kg/d of powdered activated carbon (PAC) and sulphuric acid (e.g., to pH 7.5-8.0) are added for further phenolics removal. The slurry passes through a second flocculation tank and lamella clarifier system to remove the carbon.

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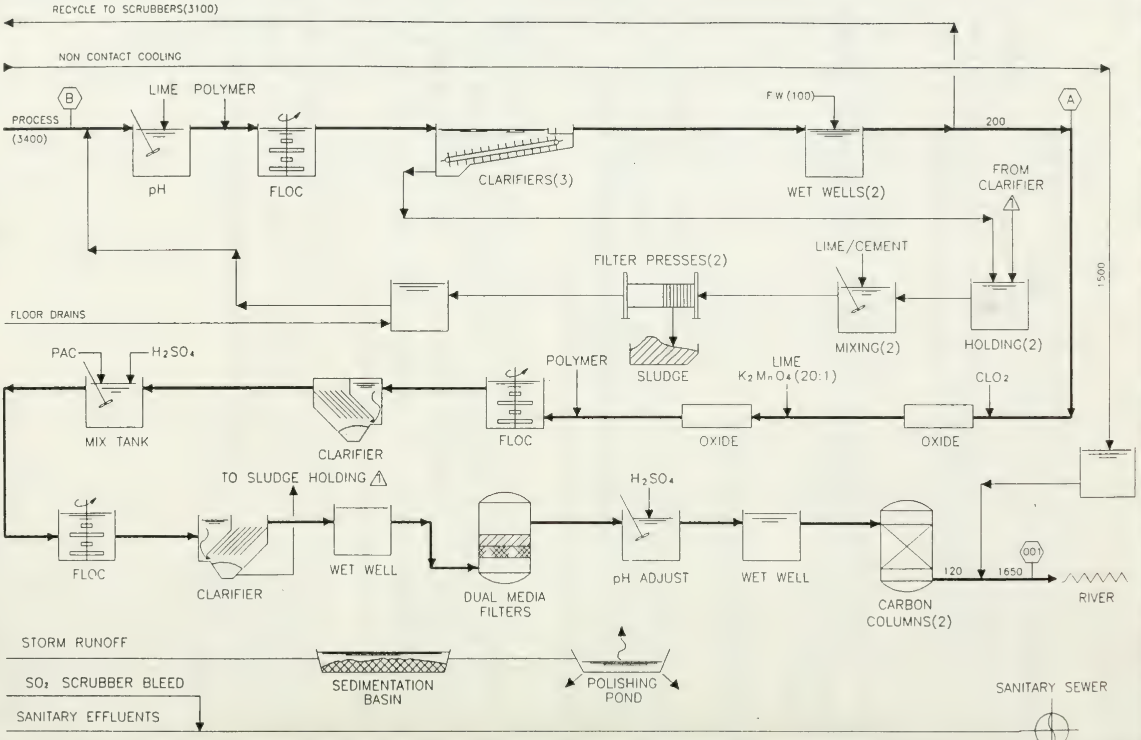

FLOW m³/d
120 →

WAUPACA
PLANTS 2 & 3

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91–5070–295

DATE MAY\92

Process effluent flows from the second lamella clarifier to a wet well from where the flow is pumped through a dual media filter for suspended solids polishing followed by the last treatment unit which consists of two activated carbon columns. The phenolics concentration is reduced to an average of 0.12 mg/L leaving the treatment system as shown in Table 6.4.

Non-contact cooling water by-passes the treatment processes and is combined with the treated effluent ahead of the final sampling station No. 001.

Storm water from the site is collected in a sedimentation basin and polishing pond. There is no direct discharge from these basins, one of which is lined and the other unlined. The basins do not overflow and the water balance is probably maintained through a combination of evaporation and infiltration.

Sanitary effluent is directed separately to the municipal sanitary sewer. About 8 m^3/d of blowdown from sulphur dioxide scrubbers (e.g., high pH, dissolved solids, sulphites and organics) used in the core production area is also discharged by agreement to the sanitary sewer.

Contaminant Discharges

Effluent data for the combined process and cooling sewers and for the process sewer alone are summarized in Tables 6.3 and 6.4, respectively. Process water discharge is 0.16 m^3/t of metal melted and the combined process/cooling flow increases to only 2.2 m^3/t.

Two sets of bioassays have been completed to measure acute lethality in the combined process and cooling flow. Non-lethal results were recorded for each of the three test organisms; fathead minnow, *Daphnia magna* and *Daphnia pulex* in the first test (May 1990). The second test used *Ceriodaphnia*, *Daphnia magna* and fathead minnow (July 1991). The LC_{50}'s were also greater than 100 percent.

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TABLE 6.3: SUMMARY OF FINAL TREATED EFFLUENT - WAUPACA FOUNDRY - STATION 001 (FINAL OUTFALL - PROCESS AND COOLING)
SAMPLING PERIOD: JANUARY 1990 - JULY 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	425	N/A	1,650	2,840	68	2.2	1.24:1
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
TSS	5.0	151	N/A	0.98	265	<1.0	1.8	1.3
pH	N/A	158	N/A	7.98	8.7	7.3	N/A	N/A
O/G	1.0	150	N/A	0.75	27.0	<5.0	1.5	1.1
Phenolics (4AAP)	0.002	150	N/A	0.007	0.680	<0.012	0.016	0.012
Cyanide	0.005	151	N/A	0.006	0.145	<0.020	0.012	0.009
Cadmium	0.002	146	N/A	N/A	0.020	<0.0001	N/A	N/A
Copper	0.010	130	N/A	0.002	0.077	<0.0032	0.0054	0.004
Zinc	0.010	131	N/A	0.001	0.16	<0.01	0.0027	0.002
Chromium (Hexavalent)	0.010	121	N/A	0.002	<0.020	<0.006	0.0027	0.002
Lead	0.03	141	N/A	0.003	0.216	<0.001	0.0068	0.005
Mercury	0.0001	144	N/A	N/A	<0.0004	<0.0002	0.000	0.000
Silver	0.030	146	N/A	0.003	<0.015	<0.0005	0.0068	0.005
Toxicity	N/A	1 1	N/A	>100% for *Daphnia magna*, *Daphnia pulex* and Fathead Minnow.* >100% for *Daphnia magna*, *Ceriodaphnia* and Fathead Minnow.				

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* See Appendix 4.

TABLE 6.4: SUMMARY OF FINAL TREATED EFFLUENT - WAUPACA FOUNDRY - STATION 101 (PROCESS OUTFALL)
SAMPLING PERIOD: JANUARY 1990 - JULY 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	455	N/A	117	189	7.4	0.16	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
TSS	5.0	143	N/A	8.7	31.8	0.93	1.4	1.3
O/G	1.0	156	N/A	6.9	28.7	3.9	1.1	0.84
pH	N/A	153	N/A	7.9	9.0	6.1	N/A	N/A
Phenolics (4AAP)	0.002	145	N/A	0.12	1.4	<0.016	0.026	0.025
Copper	0.010	155	N/A	0.035	0.13	0.023	0.0056	0.0045
Lead	0.030	155	N/A	0.0089	0.062	<0.0039	0.0012	0.0014
Zinc	0.010	155	N/A	0.058	0.97	0.0039	0.0092	0.0082

6.1.4 Foundry No. 3

Facility

Foundry No. 3 is a large facility producing grey iron, ductile iron and high carbon iron on a 130 hectare site. The plant was commissioned in 1943. Automotive parts are the product.

Two cupolas have a combined melting capacity of 3,200 metric tonnes per day. Green sand moulding is employed with shell, hot box, cold box and oil sand methods for core preparation.

Metal melting occurs five days per week, twenty-four hours per day whereas finishing operates on a six day, sixteen hour basis.

Water Use and Recycle

The plant uses 50,00 to 60,000 m^3/d of process water for melting furnace scrubbing, dust collectors and slag quenching. Large volumes of cooling water are also needed for non-contact furnace cooling, air compressor cooling and various water make-up requirements. Almost all of the process and cooling water is recycled in one of two integrated collection, treatment and recycle systems.

City water make-up entering the plant is roughly 2,700 m^3/d, 400 of which is used directly for sanitary purposes. A further 12,300 m^3/d of river water enters the main cooling reservoir to offset evaporative losses, exfiltration and blowdown. The volume of final treated effluent blowdown discharged to the local receiving water is only 3,200 m^3/d which includes most storm water.

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Effluent Management

Drawing No. 296 is a schematic flowsheet of the water recycling and treatment system at Foundry No. 3. Sanitary effluent is discharged separately to the municipal sewer system as is stormwater from non-process areas on the plant property.

One recycle system services the wet dust collectors shown at the upper half of the schematic. Dust collector effluent passes through a Sand Disposal Basin and a Decant Basin where sand and most of the suspended solids are removed. The flow then enters a 15,200 m^3 reservoir which also receives inflow from leachate collected at on-site drying beds and make-up from the cooling water and cupola scrubbing recycle system. The level in the reservoir is topped up by river water to suit the demand.

Pumping systems distribute the water back to the dust collectors and to non-contact cooling applications.

Effluent from the cupola scrubbers and slag quenching/sluicing enters a slag pit and is directed from there to a chemical flash mixing and flocculation tank just upstream from a large settling basin (e.g., 45,600 m^3). Caustic soda and waste pickle liquor (ferrous sulphate) are added to the flow in the flash mixing section of the tank (where ferrous ion is oxidized to ferric) followed by solids removal in the settling basin.

There is a process area stormwater collection pond which is used to impound and store stormwater and to bleed it gradually into the settling basin system.

Effluent from the settling basin is pumped through four multi-media pressure filters to remove fine suspended solids and is then returned to the Reservoir for recycle. This flow passes through a cooling tower when the effluent temperature is too high for direct reuse

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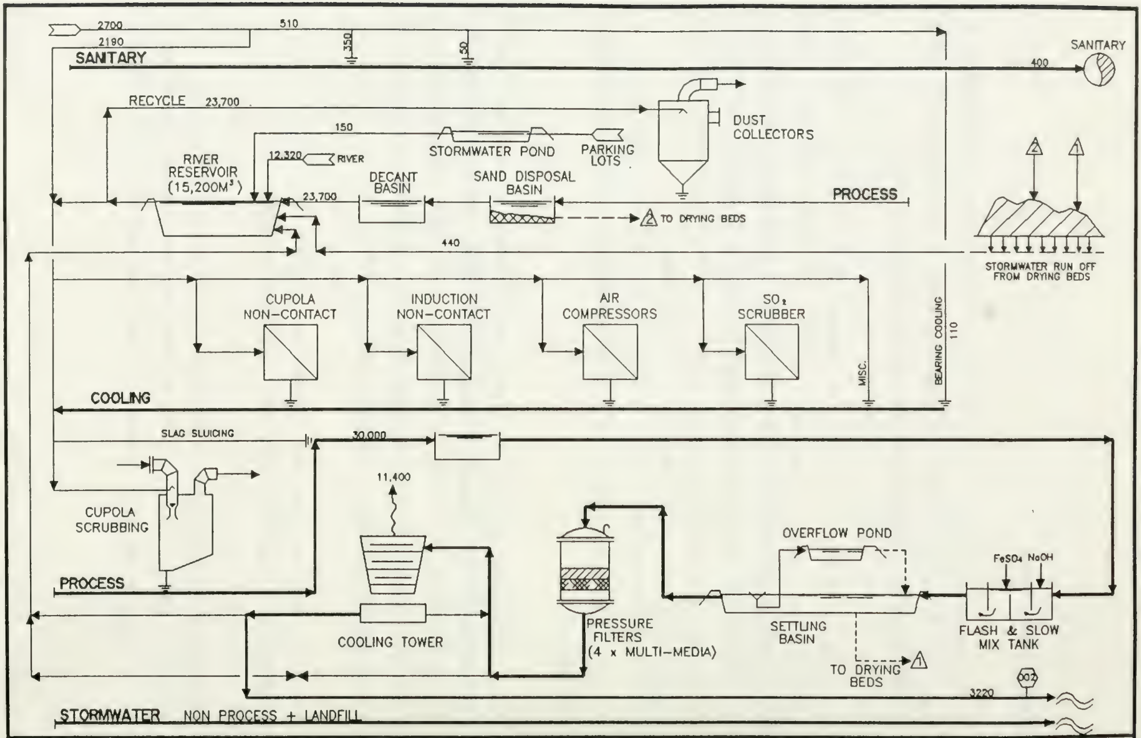

FLOW m³/d 150 →	FOUNDRY NO.3	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO. 91-5070-296 DATE OCT\92

in cooling and scrubbing. A small flow averaging 3,200 m^3/d is bled from the recycle loop and becomes the final treated effluent leaving the facility. The bleed flow controls the steady-state concentration of hardness and dissolved solids in the recycle loops.

Contaminant Discharges

Foundry No. 3 was unwilling to release monitoring data.

6.1.5 Foundry No. 4

Facility

Foundry No. 4 was originally built in 1948, employing 250 people and covering 23,000 m^2 of area. Today, this plant has a theoretical melting capacity of 10,300 metric tonnes per day, employing 4,000 people and a building area of 10 hectares on a total site occupying 176 hectares.

The facility is divided among three plants, Plant No. 1, Plant No. 2 West and Plant No. 2 East. Cupolas are the primary means of metal melting. Green sand is used for moulds and core production is via hot box, cold box and shell sand.

The main products from these plants include engine blocks and heads, carriers, crankshafts, manifolds and various small automotive parts.

Water Use and Recycle

Foundry No. 4 is a large water user for both cooling and process purposes. Process water is used for five scrubbing systems associated with the cupolas, for slag quenching and

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for approximately 96 wet dust collectors. The total process water requirement is 70,000-80,000 m^3/d. A further 90,000-100,000 m^3/d is used for cooling and miscellaneous purposes.

Virtually all of the process and cooling waters are recycled. The total volume of blowdown leaving the circulating loops as final treated effluent is only 2-3 percent of the total circulating flow as is shown in Drawing No. 297. City water supplies the 7,100 m^3/d make-up required at the facility.

Effluent Management

Sanitary effluent is segregated and discharged to the municipal sanitary system.

Stormwater from most of the site is collected in a 380,000 m^3 Secondary Basin which is a variable volume impoundment receiving the non-contact cooling flows. In this manner the stormwater is incorporated into the recycle water balance at the plant.

Non-contact cooling water is partially cooled in the clay lined Secondary Basin and then flows to a 150,000 m^3 Reservoir which is the intake for the recycle pumping stations.

The suspended solids laden process effluents from the dust collectors, slag sluicing and cupola scrubbers flow through two primary settling basins where sand and other suspended matter settles. The second basin overflows to join the cooling water in the Reservoir ahead of the recycle pump stations.

Most of the water in the Reservoir is recycled directly for process water uses. The balance of up to 15,000 m^3/d is treated with polymer ahead of three gravity sand filters. Approximately 7,500 m^3/d can then be adjusted to pH 6.8-7.1 with hydrochloric acid and softened via an ion exchange system before being recycled to the plant. A target hardness

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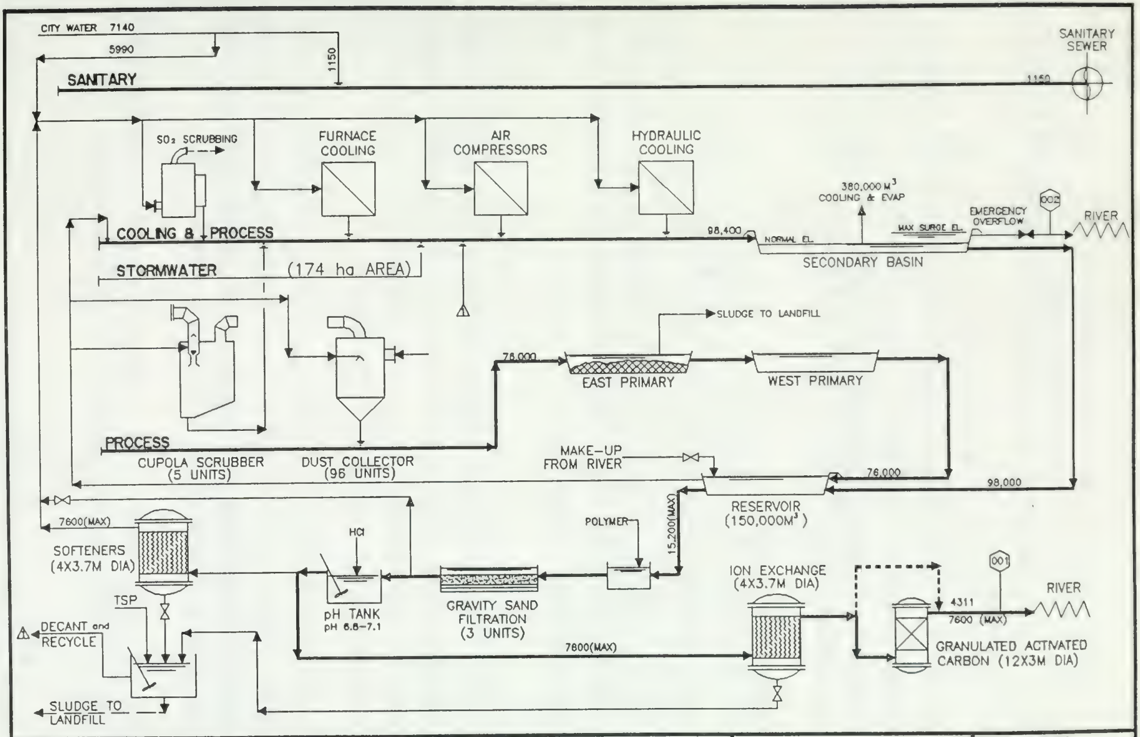

FLOW m³/d
76,000 →

FOUNDRY NO.4

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO.
91-5070-297

DATE OCT\92

of 150-175 mg/L is achieved in the non-contact recycle water by blending the softened water with unsoftened recycle water.

The remaining 7,500 m^3/d becomes a blowdown which is treated through a separate ion exchange system followed by activated carbon columns and then discharged as final treated effluent to the river. The ion exchange system is designed for copper, lead , zinc removal using Rohm & Haas resin 1718 similar to the process at Foundry No. 1.

Contaminant Discharges

Table 6.5 summarizes twenty months of final effluent discharges from Foundry No. 4. Zinc concentrations in the recirculating flow vary between 2 and 8 mg/L. Approximately 85-95% of this is removed in the ion exchange process yielding final effluent concentrations varying from 0.03 to about 1 mg/L. Other metals of interest such as copper, lead, silver and cadmium are at or well below the RMDL concentrations.

Biodegradable substances such as BOD_5, phenolics and total cyanide are relatively low in concentration but are measurable. Biological degradation is likely occurring in the large impoundments which provide over 100 days retention time based on the blowdown flow. The activated carbon columns also help to minimize the phenolics concentrations which, at an average of 0.004 mg/L, would meet Ontario standards.

Fluoride concentrations vary from 6 to 20 mg/L. Theory and experience suggest that chemical precipitation of fluoride using alum or lime is partially effective at concentrations above 4-8 mg/L fluoride but increasingly ineffective at concentrations below this range. The average final fluoride concentration is 12 mg/L as shown in Table 6.5.

Greater than 100 percent LC_{50} was the result of one set of acute bioassays using the 96-hour LC_{50} test for fathead minnows and the 48-hour LC_{50} test for *Ceriodaphnia*.

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TABLE 6.5: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: FOUNDRY NO. 4 - STATION 001 (FINAL OUTFALL)
SAMPLING PERIOD: 02 JANUARY 1990 - 08 AUGUST 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	87	N/A	4,760	7,715	410	1.72	1.6:1
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
TOC	5.0	4	0	9	12	6	11.6	32.1
BOD$_5$	5.0	4	2	8	13.0	4.0	12.7	35.2
O/G	1.0	85	12	4.4	20.0	<1.0	8.0	22.1
pH	N/A	85	0	6.85	7.47	6.35	N/A	N/A
TSS	5.0	85	56	4.8	16.8	1.2	7.9	21.8
Fluoride	0.10	4	0	12.6	20.0	5.65	21.4	59.4
Cyanide	0.005	4	0	0.018	0.055	<0.010	0.047	0.13
Phenolics (4AAP)	0.0024	85	30	0.004	0.018	<0.05	0.0079	22.1
NH$_3$-N	0.25	4	0	3.3	5.60	1.60	2.2	6.0
Aluminum	0.030	4	0	1.1	2.11	0.06	0.61	1.7
Cadmium	0.002	4	1	<0.003	<0.005	<0.001	0.003	0.001
Copper	0.010	85	0	0.005	<0.05	<0.002	0.009	0.024
Zinc	0.010	85	0	0.43	1.95	0.04	0.65	1.8
Lead	0.030	85	0	0.02	0.13	<0.01	0.034	0.095
Silver	0.030	4	4	<0.003	<0.010	<0.003	0.0036	0.01
Magnesium	0.050	2	0		157	4.70		
Chromium	0.020	4	4	<0.006	<0.01	<0.005	0.0022	0.006
Chromium (Hexavelant)	0.010	4	4	0.001	<0.01	<0.005	0.0011	0.003
Mercury	0.0001	85	0	<0.0002	0.0004	<0.0002	<0.0003	<0.001

6.1.6 Chrysler - Indianapolis Foundry

Facility

Chrysler Corporation's Indianapolis Foundry produces automotive components from grey iron, melting approximately 650 metric tonnes of metal per day. The plant employs about 1,000 people and uses municipal services for water supply and wastewater disposal.

The plant employs cupolas as melting furnaces and there are four wet dust collector systems along with a larger number of dry collectors.

Water Use and Recycle

Process and non-contact cooling water are both recirculated within the foundry. The treated blowdown from the process water system is discharged to the municipal sanitary system and averages 550 m^3/d or about 0.9 m^3/tonne of metal melted. There are separate sanitary and storm sewers contributing to the total water balance.

Chrysler personnel offered that there have been some difficulties with scaling in the recycle loops even though the recycle is partially softened and there are anti-scalants added to keep this under control.

Effluent Management

Approximately 5,000 m^3/d of process effluent is treated with lime to raise the pH to 10 to precipitate metals followed by the addition of sodium carbonate and polymer. This precipitates metals and removes non-carbonate hardness which settle as sludge in a clarifier. The sludge is dewatered using a filter press.

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Most of the clarifier effluent is recirculated to process after cooling and adjusting the pH back to 8.5 with acid.

Suspended solids are removed from a blowdown flow of 550 m^3/d via a sand filter. The pH is reduced to 7 and the flow passes through a granular activated carbon column for phenol removal prior to discharge to the municipal sewer.

Contaminant Discharge

A year's worth of discharge data for the process effluent is summarized in Table 6.6. Cadmium, copper, lead and nickel concentrations are all close to or below RMDL concentrations. The average zinc concentration is 0.062 mg/L is well below the standard for "lime settle" metals removal of 0.4 mg/L established by EPA in their Development Document for the casting industry (EPA,1985).

The average phenolics concentration is shown as 0.085 mg/L, which is well above the standard needed for direct discharge in Ontario and higher than the concentrations achieved at plants where biological treatment is employed.

6.1.7 John Deere - Waterloo, IA

Facility

The John Deere Foundry in Waterloo, Iowa was built in 1972 and produces grey iron for production of castings used in a broad mixture of automotive, railroad and general industrial equipment. The plant has six electric arc melting furnaces with a capacity for 1,780 metric tonnes of metal melted per day. Green sand moulding is used and core production uses cold box, no-bake, shell and oil sand.

Metal melting occurs twenty hours per day, Monday to Friday with finishing operations also five days per week but on a sixteen hour schedule.

TABLE 6.6: SUMMARY OF FINAL TREATED EFFLUENT - CHRYSLER, INDIANAPOLIS FOUNDRY (PROCESS OUTFALL)
SAMPLING PERIOD: SEPTEMBER 1990 - SEPTEMBER 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	304	N/A	4120	1,230	121	0.91	1.53:1
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
Phenolics	0.002	48	6	0.085	2.4	0.001	0.11	0.052
O/G	1.0	57	24	2.1	16.8	0.10	2.9	1.3
Cadmium	0.002	48	0	0.004	0.004	0.004	0.0044	0.002
Copper	0.010	48	25	0.009	0.026	0.002	0.0088	0.004
Lead	0.030	48	35	0.016	0.044	0.010	0.013	0.006
Nickel	0.020	48	36	0.006	0.006	0.006	0.0066	0.003
Zinc	0.010	48	1	0.062	0.26	0.008	0.062	0.028

Water Use and Recycle

Process water requirements are restricted to ten dust collector systems. Most of the effluent is clarified and recycled with a small controlled blowdown for dissolved solids and hardness control. Process water use amounts to 0.08 m^3/t of metal melted. This increases to 26-27 m^3/t when the cooling water discharges are included.

Effluent Management

Sanitary effluent from the plant enters the municipal sanitary sewer system.

Cooling, process and storm flows are discharged to the Cedar River via three permitted outfalls. Non-contact cooling water from the furnaces passes through an oil/water separator tank and then is discharged to the river through Outfall 006.

Air conditioning water, flows from floor/roof drains and boiler blowdown flows also pass through an oil/water separator and are discharged through Outfall 007.

The final process bleed flow of 47 m^3/d discharges through Outfall 008 and then joins the flow ahead of Outfall 007. Approximately 12,000 m^3/d of dust collector effluent is settled in a clarifier and then recycled. The blowdown flow is treated further through filters and a carbon adsorption system before discharging at Outfall 008.

Contaminant Discharges

Tables 6.7 and 6.8 summarize the effluent characteristics of the process flow alone and the combined flow of process effluent, boiler blowdown, and miscellaneous flows at Outfall 008, respectively.

TSS and oil and grease concentrations are below the EPA concentration standards used in developing the USA regulations for BAT and are also below the Ontario MISA RMDL's. Metal concentrations are less than the basis used by EPA in developing their regulations.

TABLE 6.7: SUMMARY OF FINAL TREATED EFFLUENT - JOHN DEERE FOUNDRY (STATION 008 - TREATED PROCESS)
SAMPLING PERIOD: AUGUST 1990 - AUGUST 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	244	N/A	46.9	133	6.6	0.077	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
TSS	5.0	49	43	2.3	12.4	0.4	0.21	0.13
O/G	1.0	49	34	0.69	3.4	0.1	0.061	0.037
Phenolics (4AAP)	0.002	49	5	0.24	2.56	0.0002	0.021	0.013
Copper	0.010	49	31	0.009	0.04	0.001	0.0016	0.001
Lead	0.030	49	31	0.047	0.19	0.001	0.0049	0.003
Zinc	0.010	49	30	0.014	0.14	0.001	0.0016	0.001

TABLE 6.8: SUMMARY OF FINAL TREATED EFFLUENT - JOHN DEERE FOUNDRY (STATION 006 - NON-CONTACT COOLING)
SAMPLING PERIOD: JUNE 1990 - AUGUST 1991

Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Flow				
				Average (m^3/d)	Maximum (m^3/d)	Minimum (m^3/d)	Average (m^3/tonne)	Peak Month Average
Flow	N/A	457	N/A	16,030	24,040	6,020	26.4	
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
BOD$_5$	5.0	46	46	1.3	3.68	0.15	34.6	21.0
TSS	5.0	50	37	4.4	42	0.4	170	103
O/G	1.0	52	42	0.74	6.7	0.1	19.8	12.0
48-hr LC50		1				>100% for *Ceriodaphnia dubia*.* >100% for Fathead Minnow.*		

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* See Appendix 4.

The average phenolics concentration of 0.24 mg/L in the process effluent is relatively high compared to the direct discharge objective of 0.02 mg/L in Ontario. The plant does not analyze for phenolics in the combined flow at Station 008.

6.1.8 Auburn Foundry - Auburn, IL

Facility

Auburn Foundry in Auburn, Illinois commenced operations in 1910 and has undergone many expansions and modernization upgrades since that time. It produces grey iron using one cupola and four electric arc melting furnaces with a total capacity of 1,690 metric tonnes of metal melted per day. During the time of the survey it was melting about 760 t/d to produce a wide range of cast products for the automotive, home appliance, agricultural and general industrial sectors.

Auburn employs green sand moulding and gas hardened cold box core production.

The plant occupies 6 hectares of property and operates twenty-four hours per day, five days per week.

Water Use and Recycle

Drawing No. 298 is a water use schematic of the Auburn plant which shows that there is a very high degree of water recycle. The total discharge less sanitary effluent is less than 0.5 m^3/t of metal melted based on recent production and a significant portion of this is stormwater.

Non-contact cooling water for the cupola is recycled through a heat exchanger which removes the heat via a second cooling loop employing a roof mounted air cooled exchanger as depicted in Drawing No. 298.

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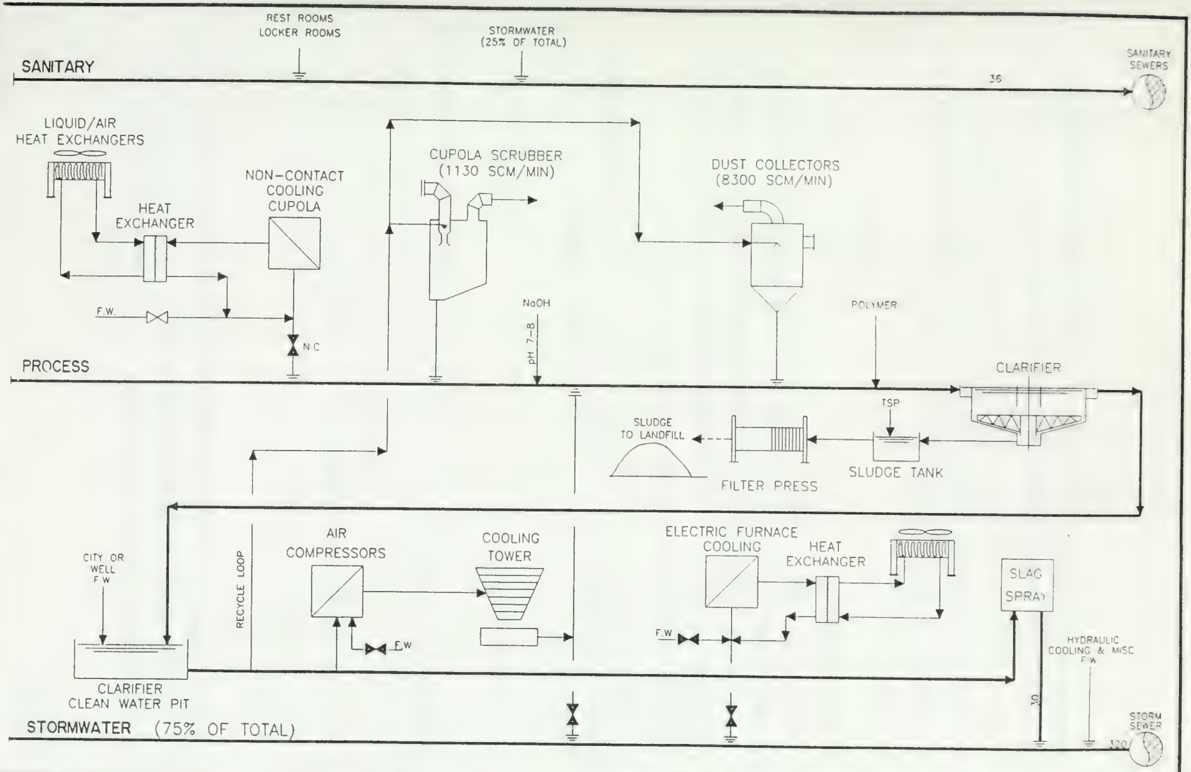


FLOW m³/d
30 →

AUBURN

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-298

DATE MAY\92

Recycle water is used for air compressor cooling. Electric furnace cooling is accomplished via a double closed cooling loop similar to that for the cupola.

City or well water is used as make-up at the clarifier clean water pit to offset losses due to evaporation on the air compressor cooling circuit and for a minor blowdown stream that is discharged to a storm sewer.

Effluent Management

Process effluent from the cupola scrubber and the wet dust collectors enters a clarifier after the pH is adjusted to 7-8 with caustic soda and after polymer addition to help settling. The clarifier effluent enters the clarifier clean water pit which is the source of recycle water back to process and to the air compressor cooling circuit.

A small blowdown flow of 30 m^3/d is used as a slag spray which then flows to the storm sewer. This blowdown represents only 0.05 m^3/t of metal melted.

Contaminant Discharges

The Auburn Foundry monitors few parameters in the plant effluent and long term data were unavailable.

6.1.9 Mitsubishi - Kobe, Japan

Facility

Mitsubishi operates a casting plant producing ductile iron, steel and stainless steel at Kobe, an industrial port city in Japan. At the time of the survey, the plant was melting approximately 24 metric tonne per day based on an eight hour day, five days per week.

This plant has characteristics of both the Wet Processing and Dry Processing Sub-Sectors as described in Section 5.0 of this report. It uses induction furnaces for melting and has no wet scrubbing of furnace exhaust. Neither are there any wet dust collectors. The plant employs investment casting which is a furan sand process using organic binders and there is some process effluent emanating from these operations.

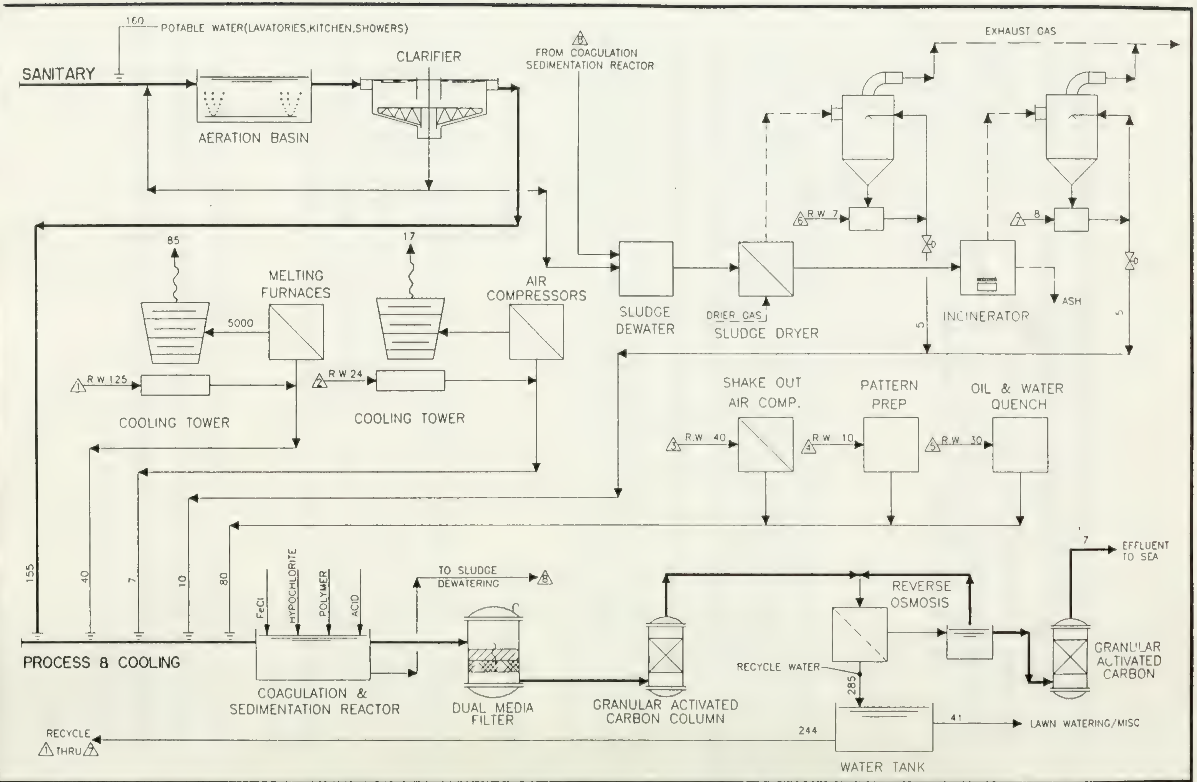
Water Use and Recycle

The Kobe plant has the most extensive effluent/water recycle of any plant found during this study and is depicted in Drawing No. 299. This is the only plant found which not only recycles process and cooling water blowdowns but also treated sanitary effluent. It is also one of only two plants found during the BAT search which is using membrane processes (e.g., in this case reverse osmosis) to maximize effluent volume reduction. The total final discharge from the plant is 7 m^3/d or 0.27 m^3/t. About 160 m^3/d of potable water from the city is the only input source and this enters the plant almost exclusively for sanitary uses (e.g., lavatories, kitchen, etc.)

Effluent Management

Sanitary effluent is treated via a conventional activated sludge process and this comprises the large bulk of the total water flow in the plant. Other sources of flow such as cooling tower blowdowns, oil and quench water and effluent from the pattern preparation area join the treated sanitary effluent upstream of a coagulation and sedimentation reactor. There are also small volumes of blowdowns from scrubbers associated with a sludge drier and sludge incinerator.

The combined flow is treated with ferric chloride, hypochlorite, polymer and acid for pH levelling in the sedimentation reactor. Sludge is removed and sent to the dewatering and drying operations. The clear supernatant passes through a dual media filter and then through a granular activated carbon column.



FLOW m³/d	MITSUBISHI (KOBE SHIP YARD)	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO 91-5070-299
80 →				DATE MAY\92

Effluent from the carbon column is the feed to a reverse osmosis system which produces 285 m^3/d of permeate and 7 m^3/d of concentrate. The permeate is the source for all recycle water to process and cooling systems and a portion is used for lawn watering.

The final concentrate volume passes through a second carbon column and the saline final product is discharged to Kobe harbour.

Contaminant Discharges

Long term data of final effluent quality were unavailable from this plant. Plant personnel indicated that TSS and Oil and Grease (e.g., hexane extractables) concentrations were generally 1 mg/L and BOD_5 was less than 1 mg/L.

6.1.10 Summary of Sub-Sector

Table 6.9 presents long term average final effluent concentration data for the majority of the US plants discussed in this section. Foundry No. 1 reported concentrations equal to or lower than any other plant in almost every case. Zinc concentration in the total effluent at the Waupaca Foundry is the only exception.

Limited toxicity data were available from two of the foundries canvassed during the survey and data from two are summarized in Table 6.10. The table presents eight separate test results for acute lethality involving fathead minnow, *Daphnia magna*, *Daphnia pulex* and *Ceriodaphnia*. All of the results were either non-lethal or were reported as LC_{50} greater than 100 percent.

The toxicity data are not conclusive but there is an initial indication that effluents from plants such as Foundry No. 1 are likely to be not acutely lethal or at least to have LC_{50}'s greater than 100 percent.

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TABLE 6.9: COMPARISONS OF EFFLUENT QUALITY - (WET PROCESSING SUB-SECTOR)

Parameter	RMDL	Long-Term Average Effluent Concentrations					
		Foundry No. 1 (mg/L)	Foundry No. 2 (mg/L)	Waupaca (mg/L)	Foundry No. 4 (mg/L)	Chrysler Indianapolis (mg/L)	John Deere (mg/L)
BOD_5	5.0	0.5	3.5[1]	NA[1]/0.98[2]	8.0[1]	NA[2]	NA[2]
TSS	5.0	0.88	2.2	8.7/NA	4.8	NA	2.3
Total-P	0.1	0.99	NA	NA		NA	NA
(NH_3+NH_4)-N	0.25	0.16	0.19	NA	3.3	NA	NA
Oil and Grease	1.0	0.10	1.2	6.9/0.75	4.4	2.4	0.69
Aluminum	0.030	0.003	NA	NA	1.1	NA	NA
Copper	0.010	0.001	0.005	0.035/0.002	0.001	0.009	0.009
Lead	0.030	0.003	0.009	0.009/0.003	0.011	0.016	0.047
Zinc	0.010	0.059	0.14	0.058/0.001	0.43	0.062	0.014
Cyanide	0.005	0.004	NA	NA/0.006	0.018	NA	NA
Phenolics	0.002	0.002	0.002	0.12/0.007	0.004	0.085	0.24
Chromium (+6)	0.010	0.001	NA	NA/0.002	0.001	NA	NA

NA - Data not available.

[1] - Process effluent only.

[2] - Process/cooling and stormwater.

TABLE 6.10: EFFLUENT TOXICITY DATA (WET PROCESSING SUB-SECTOR)

Plant	Test	Organism	Results	Test Frequency
Waupaca Foundry	Acute LC_{50}	*Ceriodaphnia*	Non-lethal	1
		Daphnia magna	Non-lethal	2
		Daphnia pulex	Non-lethal	1
		Fathead minnow	Non-lethal	2
	Chronic Survival	*Ceriodaphnia*	25/50% NOEC/LOEC	1
		Fathead minnow	100/-% NOEC/LOEC	1
Foundry No. 4	Acute LC_{50}	*Ceriodaphnia*	>100%	1
		Fathead minnow	>100%	1

NOEC = No-Observed-Effect-Concentration.
LOEC = Lowest-Observed-Effect-Concentration.

Table 6.11 compares the net effluent discharge by plant. This excludes the sanitary flow in most cases. The range of discharges varies from less than 1 m^3/t of metal melted to about 5 m^3/t with the exception of the John Deere plant which is higher. To put these data into perspective, it must be remembered that the effluent discharges at the Ford, Windsor plant and at the General Motors, St. Catharines plant are in the order of 90-110 m^3/t.

It has been demonstrated clearly at one or more of the plants cited in Table 6.11 that almost any water stream in a wet processing foundry can be treated and recycled including process effluent, cooling flows and stormwater. There is still a large variation among individual plants that will influence the ultimate extent of recycle possible. Factors such as evaporation from large holding basins also become important components of the water balance at plants such as Foundry Nos. 1, 3 and 4.

Foundry No. 1 is recommended as the BAT model for Best In The World, Best In The US, Closest To Virtual Elimination and Best For Eliminating Acute Lethality. This BAT can be implemented at Ontario plants but with a total effluent flow basis somewhat higher than the 1 m^3/t of metal melted as observed at Foundry No. 1.

6.1.11 Effluent Variability

MOE requires statistics called "Variability Factors" to be determined before effluent limits can be set. The 30-day, the 4-day and the 1-day Variability Factors (e.g., VF(30), VF(4) and VF(1)) are the key statistics required for this purpose. The method of screening sets of data and of calculating variability factor values is defined in MOE's Issue Resolution Documents (MOE, 1991).

To address this concern, the variability factors for Foundry No. 2 have been examined along with Foundry No. 1 data. The Foundry No. 2 database was extensive and the fundamental treatment process was almost identical to that at Foundry No. 1 for the last unit operation. The VF(30) and VF(4) variability factors for both plants are presented in

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TABLE 6.11: EFFLUENT QUANTITIES (WET PROCESSING SUB-SECTOR)

Plant	Metal	Process Effluent (m^3/t)	Combined Effluent (m^3/t)
John Deere	Grey Iron	0.08	26.5
Chrysler Indianapolis	Grey Iron	0.91	NA
Foundry No. 2	Aluminum	-	3.8
Foundry No. 4	Grey Iron	-	1.7
Waupaca	Grey and Ductile Iron	0.16	2.2
Foundry No. 1	Grey Iron	-	0.98
Mitsubishi, Kobe	Ductile Iron, Stainless Steel	-	0.27
Auburn, Auburn	Grey Iron	-	0.47

NA = Not available.

Table 6.12. The higher of the two sets of factors has been used in Section 8.0 of this report where predictions of performance are made for the BAT cases which use Foundry No. 1 as the model. In some cases, the VF(30) and VF(4) data are marked as "Not Available" and VF(1) is shown as 1.0. This is usually caused by a set of analytical data which are all at or below the RMDL. This is the case for BOD_5, copper and lead data for Foundry No. 1.

Appendix 2 contains tables of variability factors calculated with MOE's assistance using the operating data from several of the BAT candidate plants.

Daily effluent analysis is not required at Foundry No. 1 as the final treated effluent is discharged to the City sanitary sewer. This raises the question of the reliability of the variability analysis with this limited data set.

6.2 Dry Processing Sub-Sector

6.2.1 DuPage Die Casting

Facility

DuPage Die Casting and Fabricating Co. operates an aluminum alloy die casting plant in Niles, Illinois. The plant was built in 1961 and it has four gas/reverberatory melting furnaces with a maximum melting capacity of 78 metric tonnes of metal per twenty-four hour day. DuPage's finished products are primarily for the automotive industry.

Normal operations at the plant comprise melting twenty-four hours per day, five days per week. Finishing operations are on a sixteen hour per day schedule. Finishing includes trimming, machining and casting cleaning steps.

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TABLE 6.12: VARIABILITY FACTORS - (WET PROCESSING SUB-SECTOR)

	Foundry No. 1			Foundry No. 2		
Parameter	**VF(30)**	**VF(4)**	**VF(1)**	**VF(30)**	**VF(4)**	**VF(1)**
BOD_5	NA	NA	1.0	1.5	2.5	7.2
(NH_3+NH_4)-N	1.2	1.4	2.5	1.5	2.3	8.0
Oil and Grease	NA	NA	1.0	1.8	3.2	11.3
TSS	1.4	2.2	5.7	1.4	1.9	5.0
Total-P	1.4	1.5	1.7	NA	NA	NA
Copper	NA	NA	1.0	1.4	1.9	4.0
Lead	NA	NA	1.0	1.3	1.8	4.1
Zinc	1.4	1.4	1.7	1.2	1.4	2.4
Phenolics	1.7	2.0	3.0	2.7	5.2	3.8
Cyanide	1.2	1.4	2.3	NA	NA	NA

VF(30) = Calculated 30-day variability in the effluent pollutant concentration around the Long-Term Average for parameters measured daily or frequently.

VF(4) = Calculated monthly variability in the effluent pollutant concentration around the Long-Term Average for parameters measured weekly (e.g., 4 times per month).

VF(1) = Calculated 99th Percentile variability around the Long-Term Average concentration.

NA = Not available.

This plant was contacted as it has operated as a "Zero Discharge" plant for the past two years.

Water Use and Recycle

Water use at DuPage is limited to cooling operations and one or two minor process applications. The plant is otherwise a dry operation and there are no wet scrubbing or dust collection processes.

City water from Lake Michigan is the water source for the plant. Only the sanitary effluent is discharged to the municipal sewer; all remaining incoming water is recycled and ultimately evaporated or concentrated in sludges which are disposed of off-site.

The primary water loop is the cooling water employing an evaporative cooling tower for the die cast machines and die cast heat exchangers. It is uncertain whether this loop also provides non-contact furnace cooling. Small quantities of blowdown for dissolved solids control enter the plant sewer and are processed through the recycle treatment system.

Die spray which accumulates in the sumps or pans under the die casting machines is the main source of contaminated effluent. This material accounts for about 10-15 m^3/d of volume and contains die lubricants and surfactants in a water base. This is collected in a centralized collection tank which also receives any liquid flow discharged to the plant floor drains including the cooling loop blowdown and some spent hydraulic fluids. An oil skimmer removes the free oil.

Liquid from the collection tank is sent to an evaporator where approximately 99 percent of the flow is evaporated and then condensed for re-use and the remaining 1 percent is collected into a drum for off-site disposal. This step removes dissolved solids and most of the surfactants which would otherwise build up in a recycle loop.

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An ultrafilter follows the evaporator. Ninety-nine percent of the condensate feed to this unit enters the permeate of the ultrafilter and is recycled to the die spray make-up tank where it can be used in place of city water. The concentrate is collected and shipped off-site similar to the evaporator bottoms.

The ultrafilter unit was installed several years ago when the small flow of process effluent was entering the municipal sewer. The effluent failed to meet the local sewer bylaw governing phenolics and the ultrafilter was installed as a first attempt to concentrate the phenolics in the "Oil and Grease" fraction of the effluent. This was not successful as the process was unable to partition the organic compounds and recycle of the permeate caused a build-up of surfactant and dissolved solids in the die spray. This sparked the addition of the evaporator. Plant personnel are presently investigating whether ultrafiltration is providing any benefit to the recycle process.

The plant had not discharged any process effluent to the municipal sewer for over two years at the time of the survey.

6.2.2 Chicago White Metal

Facility

Chicago White Metal of Bensenville, Illinois is an aluminum, zinc and magnesium die casting facility. Although the survey response from this plant was only partially complete, the effluent management system described is typical of many die casting plants and other relatively dry foundries.

Chicago White Metal operates ten die casting machines, each of which has a quench tank that doubles as a collection sump for the die spray solutions. There are no other wet processing steps.

Bensenville municipal well water is the water source for the plant. It is used primarily for sanitary facilities, for make-up to the quench tanks, and a cooling tower system used for die casting machine cooling, and possibly other minor cooling operations.

Effluent Management

Sanitary effluent is directed to the Bensenville municipal sewer.

Process effluent comprising liquid from the quench tanks is pumped into a batch treatment tank. Acid is added to pH 6, as well as a polymer and a dry oil adsorbent material. The tank contents are then filtered through a disposable paper filter to remove the adsorbed oil and grease and flocculated metals.

Filtrate enters a second batch tank where caustic soda is added to raise the pH slightly before the batch is discharged to the sanitary sewer.

Plant personnel reported that there is rarely any blowdown from the cooling tower system. Flowsheets provided by the company indicate that any blowdown would be discharged directly to the sewer.

6.2.3 Summary of Sub-Sector

The preceding examples of Chicago White Metal and DuPage Die Casting show that there are methods in use to treat and or eliminate the small volumes of process effluents generated by die casting plants. Detailed operating and effluent data have been difficult to acquire because the large majority of plants in the dry processing sub-category have no effluent or have only small volumes which are rarely if ever monitored and are discharged with sanitary effluents into municipal sanitary sewers.

It is apparent from the data at plants in Ontario that once-through cooling waters can contain small concentrations of contaminants not initially present in the intake water supply. It is equally clear that virtually all once-through cooling can be replaced with recycle cooling of one sort or another if there is a financial or regulatory incentive. The product is either a small quantity of blowdown from evaporative cooling systems or no blowdown for systems that are completely closed and not based on evaporative processes.

It is the observation of this study that there is a very broad acceptance world wide by municipal authorities to accept the discharge of small quantities of process blowdowns and effluents from the die casting and dry process foundry industry into municipal sanitary sewers. In this regard, "zero direct discharge" is a demonstrated achievement within the sector for plants that are on municipal sanitary systems. In rare cases where sewer ordinances prohibit these residues, such as reported for DuPage Die Casting, it is technically possible to use evaporation or other processes as a means of volume reduction to a point where off-site disposal of the concentrate volume can be considered.

The volume reduction offered by processes such as evaporation does not necessarily provide an improved treatment technology. There are virtually no data available to show that shipment and treatment off-site of small volumes of concentrated waste produced in a casting plant provide a more effective or less effective control of contaminants than would otherwise be provided if the effluent were discharged to a sanitary treatment process.

6.3 Haley Industries Sub-Category

6.3.1 Magnesium Casting Sector in General

A directory of all casting plants in North America was reviewed to identify facilities with production processes and products similar to Haley Industries. Sixteen magnesium casting plants producing finished products for the aerospace or similar industry were short listed

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from the 1991 American Foundryman's Directory. Several of these were contacted to determine which of the plants produced effluents similar to the effluent at Haley and whether any employed more advanced treatment processes.

It was found that none of the plants was a direct discharging facility. All facilities discharged their sanitary and process effluents into municipal sanitary sewers. The telephone interviews revealed that none had treatment processes as complex as those in place or planned at Haley, partly because the magnesium sector was left unregulated in the recent EPA regulation owing to the financial impact on that sub-sector. Plants are only required to meet their local sanitary sewer bylaws and there was little monitoring data available to review in any case.

This result forced a broader search for an industrial discharger with an untreated effluent quality representative of the effluent at Haley. Effluents generated at Martin Marietta's aerospace and defense contracting facility at Waterton, Colorado were found to have a strong similarity to the untreated effluent at Haley. The facility and its treatment systems are described in Appendix 3.

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7.0 OVERVIEW OF AVAILABLE TECHNOLOGIES

7.1 Chemically Assisted Clarification

Chemically assisted clarification is defined for this industry sector as hydroxide precipitation with or without polymer addition followed by sedimentation in a mechanical clarifier or settling basin. It is normally used as the initial treatment step for removing metals, suspended solids and oil and grease.

The EPA Development Document for the metal casting industry presents a summary of treatment efficiencies that can be achieved with this technology based on long-term operating data from several plants (EPA, 1985). The EPA document refers to the "Lime Settle" technology or unit operation. The data base developed included information from plants which used hydroxide based chemical addition (e.g., usually lime or alum) in a pH range between 7.0 and 10.0 and for which the influent metal concentration was 0.1 mg/L or higher.

Table 7.1 presents the long-term average concentrations achievable for copper, lead, zinc, oil and grease and total suspended solids after lime settle treatment as summarized in Table VII-12 of the EPA report. Phenolics were included in the EPA results but have been excluded from Table 7.1 as the Environment Canada performance review of the Ontario casting plants demonstrated that phenolics were unaffected by chemical assisted clarification (Env. Canada, 1991).

Calcium triple super phosphate (TSP) is another chemical which is used at several foundries described in Section 6.0. The original purpose was to add TSP to process flows from dust collectors and scrubbers to help immobilize heavy metals in the settled sludges. This has permitted many foundries to pass the EP Toxicity protocol and enable a reclassification of sludge from hazardous to non-hazardous. A secondary effect of TSP addition is to help control hardness and alkalinity build-up in recycle loops. The phosphorus added with TSP dosing must be removed from solution during treatment of the blowdown.

TABLE 7.1: CHEMICAL ASSISTED CLARIFICATION (Treated Effluent Quality - EPA 1985)

		Long-Term Average Concentration	
Parameter	**Units**	**Ferrous Sub-Category**	**Non-Ferrous Sub-Category**
Total Suspended Solids	mg/L	10	10
Oil and Grease	mg/L	5	5
Copper	mg/L	0.065	0.17
Lead	mg/L	0.22	0.22
Zinc	mg/L	0.40	0.27

7.2 Chemical Oxidation/Reduction

Several chemical oxidation and reduction processes are used to treat contaminants relevant to the metal casting industry. Following are the most common chemicals encountered for redox reactions at full scale during the present study:

Potassium Permanganate:	Oxidizes phenolics (4AAP) and cyanides;
Chlorine Dioxide:	Cyanide oxidation;
Hydrogen Peroxide:	Oxidation of nitrite to nitrate and ferrous ion to ferric ion;
Na Metabisulphite:	Reduces hexavelant chromium to trivalent chromium; and
Ferrous Ion:	Reduces hexavelant chromium to trivalent chromium.

Potassium permanganate oxidation of phenolics was reported by EPA as effective in reducing phenolics from an initial concentration range of 0.1-1.0 mg/L to 0.022 mg/L and lower. Although this would be roughly equal to or better than the limit of 0.02 mg/L currently required in Ontario for direct discharge, the permanganate dosages needed are high. The EPA reported dosages in the order of 20:1 to 80:1 permanganate to phenolics (EPA, 1985). A 20:1 permanganate to phenolics dosage is the target at the Waupaca Foundry. The phenolics concentration is decreased from an initial range of 15-20 mg/L entering the chlorine dioxide oxidation reactor and leaves the permanganate oxidation reactor at 0.3-2.0 mg/L (MOE trip report).

Sodium metabisulphite is the most common reducing agent in use for reducing the highly toxic $Cr^{+}6$ to $Cr^{+}3$ before coagulation and settling. It is customary to add sufficient chemical such that the residual concentration of $Cr^{+}6$ is below the detection limit.

7.3 Carbon Adsorption

The use of activated carbon, either granular or powdered, to remove dissolved organic compounds from wastewater is a long demonstrated technology and is used at a number of the casting plants reviewed in this document. Its use in this industry is primarily to reduce phenolics concentrations to meet the EPA Regulation in the United States.

Carbon adsorption is used at the Waupaca Foundry, at John Deere, Waterloo and at the Chrysler, Indianapolis Foundry. The long-term average concentrations of phenolics in the carbon treated effluents as reported in Section 6.0 varied from a low of 0.097 mg/L at Chrysler to a high of 0.26 mg/L at John Deere. Influent concentration data were not available in all cases.

7.4 Biological Treatment

Extended aeration and rotating biological contactors (RBC's) are two biological processes in use at foundries for treating dust collector and scrubber blowdowns containing phenolics

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and other compounds contributing to BOD_5. The concentration of phenolics in the treated effluent of the extended aeration systems at Foundry Nos. 1 and 2 are generally reported close to or below the method detection limits signifying complete removal. The average concentrations were less than 0.003 mg/L and less than 0.013 mg/L at Foundry Nos. 1 and 2, respectively.

The use of extended aeration at these two plants is a somewhat unconventional application of the process owing to the dilute nature of the influent (e.g., BOD_5 concentrations less than 100 mg/L). This has been overcome at Foundry No. 1 by the use of sufficient alum for phosphorus precipitation in the aeration basins that the suspended solids provided by the alum floc help to create and maintain an adequate concentration of mixed liquor suspended solids in the aeration tanks.

The proper application of almost any other aerobic biological treatment process should be able to perform equally in place of extended aeration. The required conditions are that a long sludge age must be maintainable and that hydraulic short-circuiting be prevented. Processes such as RBC's, trickling filters, aerated biological filters and Sequencing Batch Reactors (SBR's) to name a few are theoretically suitable candidates even if not specifically employed in foundries to date. Careful attention is needed in the selection of the proper biological process.

The RBC system treating the hot coat muller dust collector flow at General Motors in St. Catharines has been successful in reducing phenol concentration. The conclusions from a 12-month phenolics sampling program at the foundry in 1988 included the following (BEAK, 1990):

1. That 65-70 percent phenolics removal was being achieved in the RBC.

2. About 84 percent of the total phenolics load in the foundry effluent was contained in 0.1 percent of the process flow comprising the RBC feed.

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3. Phenolics reductions, probably through biological activity, were occurring at each step of the foundry's effluent treatment process.

4. The total phenolics discharge in the final effluent to the receiving water was 75 percent lower when the RBC was operating, compared to periods when it was not operating.

The phenolics concentration entering the RBC averaged 1,000-1,500 mg/L and the load was 15-20 g phenolics per square metre of disc area per day. Several process problems including hydraulic and phenol concentration surges and possible nitrogen deficiency were suggested during the study. These may have partially explained why the phenolics removals of 95 percent and higher anticipated from the earlier bench and pilot testing were not achieved at full-scale. General Motors personnel have also indicated that additional process difficulties such as loss of biofilm have been encountered during the last two years. There has been some change in the phenolic resins used during this interval.

Aerated or facultative stabilization basins are also suitable if designed properly and if the winter operating temperatures are kept sufficiently high. In practice there is little opportunity for this type of biological process at Ontario plants owing to the land requirements.

7.5 Suspended Solids Polishing

Sand filters, dual media filters and pressure filters are used in the casting industry to reduce suspended solids concentrations. This unit operation is generally employed after a primary clarification step or following the secondary clarifier in a biological treatment process. It can be used in treating process flows before recycle to process or in treating the final blowdown flow.

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The EPA Development Document reported that granular bed filters were in use at 32 casting plants in the United States (EPA, 1985). A long-term average concentration of 2.6 mg/L of TSS leaving the filter was established as the basis for filter performance in EPA's definition of "Option 3" performance (i.e., Table VII-14 in EPA document). Table 7.2 summarizes the operating data that EPA cited as the basis for this standard. The EPA review also concluded that granular media filtration had little or no measurable effect in removal of metals such as copper, lead and zinc.

TABLE 7.2: TSS CONCENTRATIONS WITH GRANULAR MEDIA FILTRATION (EPA 1985 - Table VII-16)

Plant Code	**Average Filter Effluent (mg/L)**
06097	0.17
13924	3.3
18538	1.0
30172	3.1
36048	2.1
Mean	**2.6**

7.6 Ion Exchange

7.6.1 Silver Removal

Removal of silver from spent fixer solutions and rinsewaters associated with X-Ray developing operations is an issue at casting plants where X-Ray techniques are used for quality control. Most photographic and X-Ray developing systems employ an electrolytic process to recover spent silver from the fixing solution. The incentive for this process has historically been economic especially when silver prices were higher than at present.

The electrolytic process becomes inefficient as silver concentration decreases and it is not generally used to recover traces of silver remaining in the final rinse step which becomes a process discharge. Several ion exchange systems have recently been gaining wider use as an add-on process where silver discharges are environmentally unacceptable. Table 7.3 provides operating data from three systems provided by two different equipment suppliers.

TABLE 7.3: SILVER REMOVAL BY ION EXCHANGE

		Plant		
	Units	Providence Journal	Coors Brewing	Martin[1] Marietta
Supplier		AgMet	AgMet	Pacex
Flow	L/s	0.50	0.25	0.20-0.25
Influent	mg/L	1.47	7.34	0.074
Stage 1 Effluent	mg/L	0.26	NA	0.015
Stage 2 Effluent	mg/L	0.0090[2]	0.0154	0.002-0.004
Total Removal	Percent	99.4	99.8	98

[1] Each stage contains two columns in series.
[2] 39 of 48 observations were less than the detection limit of 0.014 mg/L.

Final silver concentrations at or below 0.010 mg/L appears to be achievable in the combined spent fixer/rinsewaters with this process. The flow from this area is usually a tiny fraction of the total effluent generated at a casting plant which means that the final silver

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concentration in the combined effluent could be an order of magnitude or more lower than shown in Table 7.3.

7.6.2 Copper, Lead and Zinc Removal

Table 7.4 summarizes the limited data available from Martin Marietta at Waterton and from Foundry No. 4 showing the efficacy of the ion exchange systems used as a final treatment step. Zinc is the metal of primary concern at Foundry No. 4 and regular influent and effluent analyses are completed to track general performance and to watch for column breakthrough. Zinc removal is usually over 90 percent through the single stage ion exchange system and residual concentrations of zinc vary between 0.01 and 0.4 mg/L. Influent zinc is relatively high at 4-10 mg/L.

TABLE 7.4: COPPER AND ZINC REMOVAL BY ION EXCHANGE

	Foundry No. 4			**Martin Marietta**		
Substance	**Influent (mg/L)**	**Effluent (mg/L)**	**Removal (Percent)**	**Influent (mg/L)**	**Effluent (mg/L)**	**Removal (Percent)**
Copper	NA	NA	NA	0.06	<0.01	>80
Zinc	4-10	0.01-0.4	90-95	0.06	<0.01	>80
Calcium	NA	NA	NA	57	56.8	0

NA = Not available.

The data from Martin Marietta reflects eight sampling events. The two ion exchange columns were operating in series at the time of sampling and the overall system removal

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was greater than 80 percent for both copper and zinc. Final concentrations were below the method detection limit of 0.01 mg/L.

Notice that the concentration of calcium at Martin Marietta was unaffected by the ion exchange resin. The Rohm & Haas IRC 718 resin used in both of the above systems is also used in the ion exchange process at Foundry No. 1. The selectivity for heavy metals, and particularly bivalent metals, while leaving calcium and magnesium unaffected is the unique feature which has allowed ion exchange to be technically and economically feasible at these plants.

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8.0 BAT CANDIDATES

8.1 Wet Processing Sub-Sector

8.1.1 BAT 1 (Best in Ontario)

The General Motors Foundry and Engine Plant in St. Catharines is identified as the BAT 1 (Best in Ontario) plant for this sub-sector. The selection is based on a comparison between Ford and General Motors only.

While plants such as Canada Pipe in Hamilton and the Crowe Foundry have implemented excellent programs of process effluent recycle, these plants are no longer direct dischargers and there are no long term flow or effluent data available (e.g., discharge is to sanitary sewers).

Table 8.1 presents summary information of the long term average discharges for Ford and General Motors expressed as discharge per tonne of metal melted and as concentration. Data for both the process effluents alone and the combined plant effluents (e.g., process, cooling, storm) are provided. In almost all cases the final concentrations and the mass discharges at General Motors are lower.

The parameters included in Table 8.1 are restricted to those where the treatment processes utilized have been shown effective in reducing discharges (Environment Canada, 1991b and some in-plant study reports).

The main treatment technologies associated with this BAT candidate plant are as follows:

1. Suspended solids removal from process effluent via chemically assisted flocculation/coagulation in a mechanical clarifier.
2. Partial biological treatment of phenolics contained in dust collector effluent.
3. Oil removal/skimming basin for total combined effluent.

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TABLE 8.1: SUMMARY OF ONTARIO DISCHARGES - WET PROCESSING

	Total Combined Effluent (Long-Term Average Data)			
	Mass Basis		**Concentration**	
Parameter	**Ford (g/t)**	**G.M. (g/t)**	**Ford (mg/L)**	**G.M. (mg/L)**
Combined Final Effluent[1]				
Flow (m^3/T)	114	90	114	90
Suspended Solids	1,590	1,450	13.5	14.6
Oil and Grease	255	160	2.2	1.8
Total Phosphorus	3.4	7.1	0.031	0.082
Aluminum	99	49	0.82	0.54
Cadmium	0.39	0.17	0.0033	0.0019
Copper	1.5	0.51	0.013	0.0057
Iron	72	61	0.60	0.67
Lead	6.5	2.7	0.054	0.029
Zinc	110	35	0.89	0.39
Phenolics	27	4.3	0.22	0.051
Process Effluent				
Flow (m^3/t)	46	48	46	48
Suspended Solids	920	430	18.7	8.9
Oil and Grease	98	71	2.0	1.4
Total Phosphorus	1.2	9.6	0.027	0.18
Aluminum	81	29	1.6	0.66
Cadmium	0.36	0.13	0.007	0.0027
Copper	0.98	0.22	0.02	0.0048
Iron	60	34	1.2	0.73
Lead	6.8	2.9	0.13	0.56
Zinc	110	35	2.0	0.66
Phenolics	29	4.2	0.54	0.078

---

[1] For General Motors: Process, cooling, storm and sanitary.
For Ford: Process, cooling, most storm runoff and oily waste treatment plant decant.

8.1.2 BAT 2-5

Foundry No. 1 is identified as the facility best satisfying the criteria for BAT 2 through BAT 5 which includes the following:

- Best in the USA;
- Best in the World;
- Closest to Virtual Elimination; and
- Best for Non-Lethal Effluent.

The main treatment technologies associated with this BAT plant are as follows:

1. Clarification, cooling and recycle of all process effluents to dust collectors, scrubbers, sluicing or quenching.
2. Collection, evaporative cooling and recycle of most non-contact cooling waters.
3. Collection and recycle of storm runoff from outside process or material storage areas.
4. Oil removal from the total recycle flow.
5. Extended aeration treatment of a controlled blowdown from the recycle system with alum to provide mixed liquor bulk and phosphorous removal.
6. Tertiary filtration of the clarifier effluent following biological treatment.
7. Ion Exchange of the final effluent using a selective resin for heavy metals polishing.

The terms of this BAT review specifically required the inclusion of any demonstrated technologies which reduce the total amount of water use or discharge. It is for this reason that the recycle of non-contact cooling water has been included. It is not demonstrated that changing from once-through cooling to closed cooling loops necessarily reduces contaminant discharge or is the environmentally appropriate action in all cases. Evaporative cooling systems generally employ anti-scalant chemicals and bactericides which are not necessarily needed in a once-through process. In many cases the majority of the contaminant concentrations present in once-through cooling discharges are simply carried through from the intake water supply.

8.1.3 Other Process Options

There is a large gap in the application of demonstrated technology between the BAT 1 plant and the BAT 2-5 plant. Several treatment options which provide a step-by-step move from BAT 1 toward BAT 2-5 are presented in this section as examples of how various components of the BAT 2-5 technology could be implemented.

Drawings No. 300 and 301 are simplified schematic flow diagrams of BAT 1 and BAT 2-5 as they could apply to the Ontario plants. Drawings No. 302 to 305 present process options numbered 1 through 4. The specific process configurations in Options 1-4 have not been presented as formal BAT options as a specific model plant with the required long term operating data was not found for each of these during the study. Nevertheless, the technology components employed by each are all in use at the BAT 2-5 plant. These options are included in the estimates of capital cost for implementation which are presented in Section 9.0.

Option 1: This modification introduces a recycle system for process water with a blowdown of 1 m^3/t. With the exception of partial biological treatment, Option 1 is the same as the BAT 1 (Best in Ontario) plant.

Option 2: This option is depicted in Drawing No. 303 and presents the same treatment process used by the BAT 2-5 plant, but for the process effluent only. Storm flows and cooling waters would bypass treatment except for oil removal and there would be no flow reduction for these streams.

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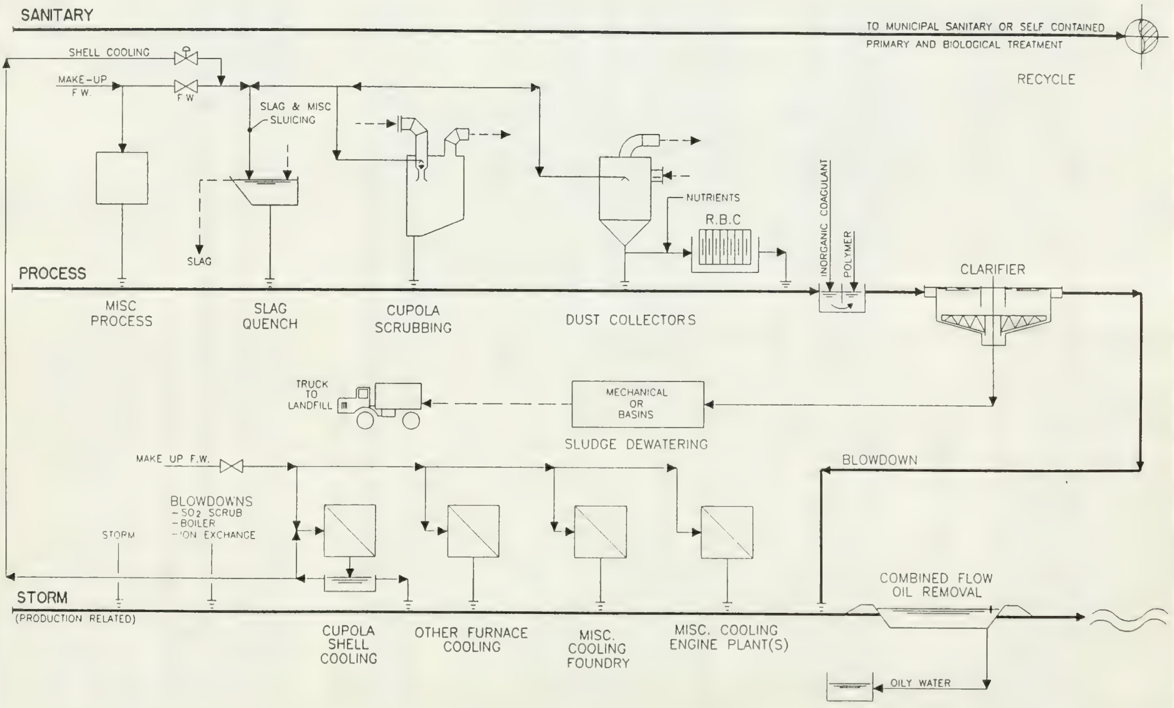
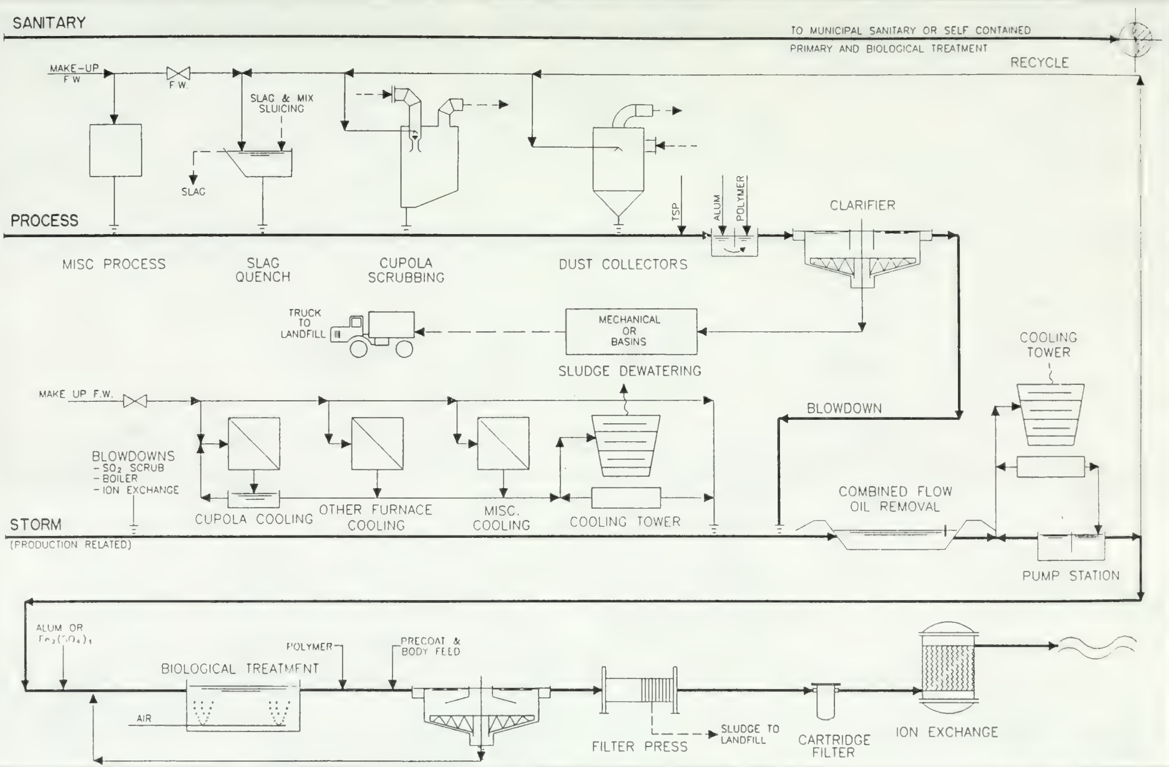


BEST IN ONTARIO
(WET SUBCATEGORY)
BASIS: GENERAL MOTORS

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO.
91-5070-300

DATE MAY\92

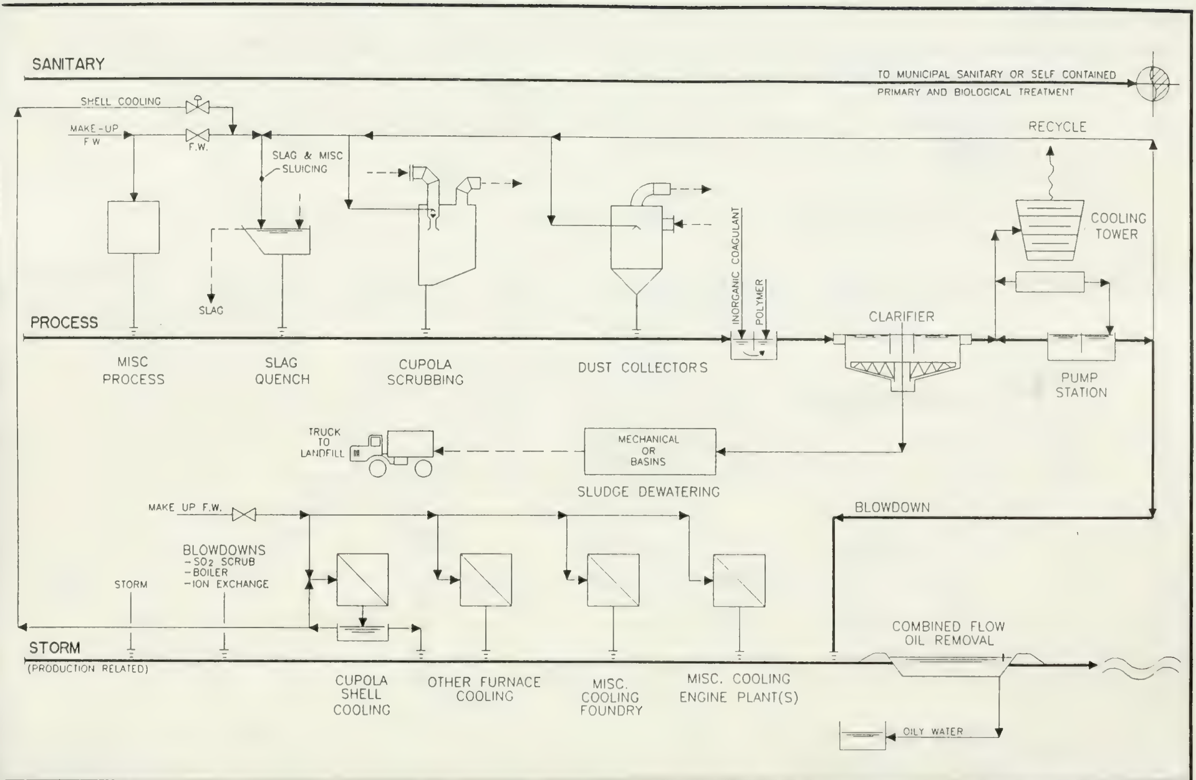


BEST IN THE WORLD
(WET SUBCATEGORY)

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-301

DATE MAY\ 92



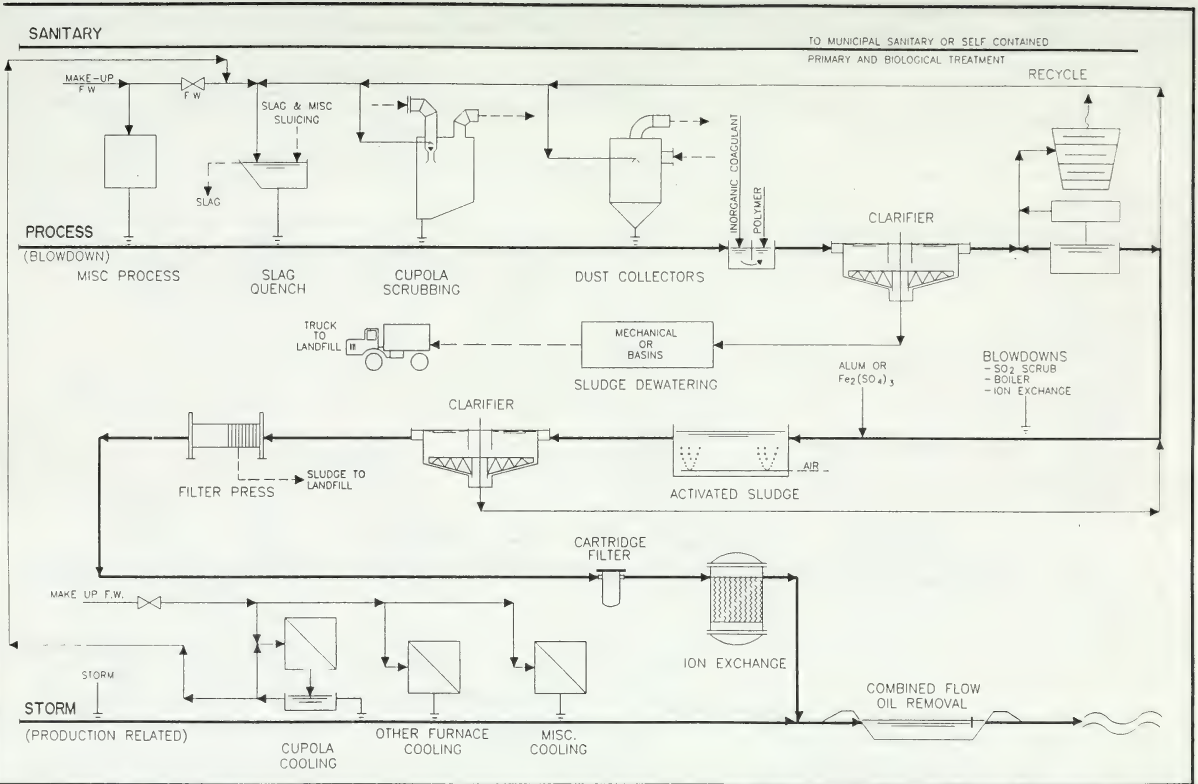
PROCESS OPTION 1

(PROCESS EFFLUENT RECYCLE)

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING No
91-5070-302

DATE MAY\92

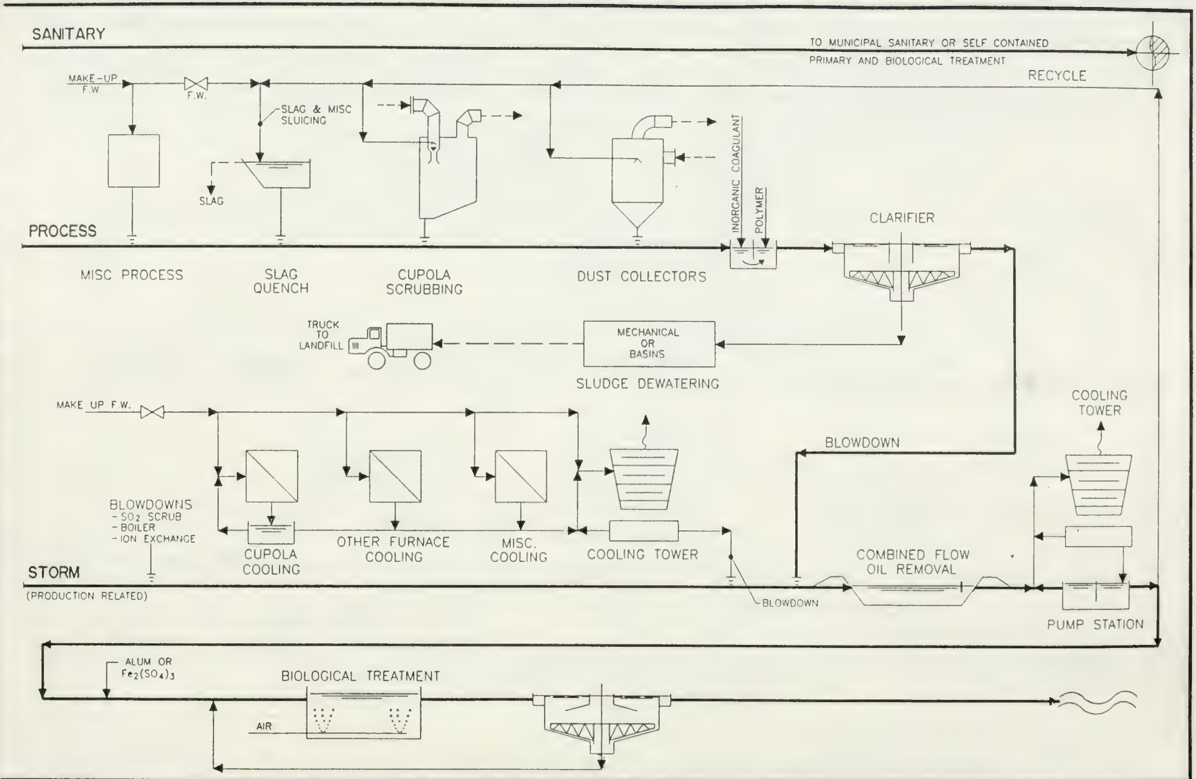


OPTION 2

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-303

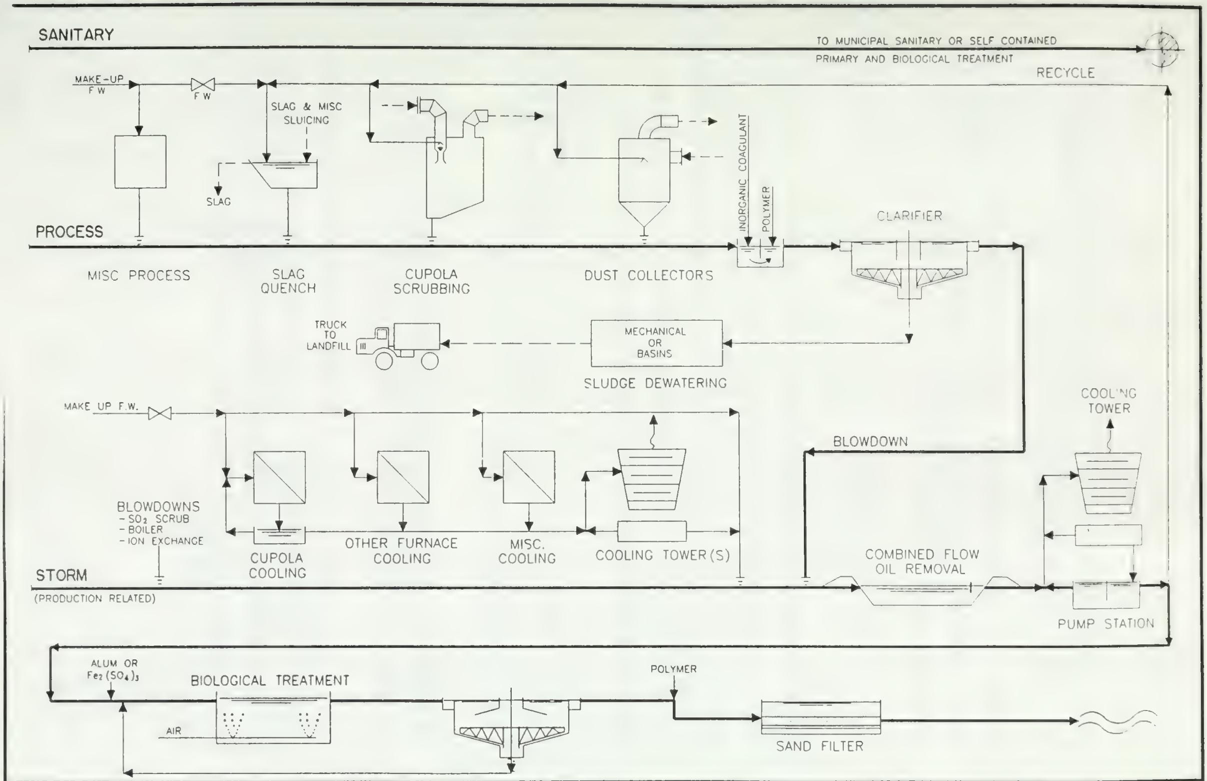
DATE
MAY\92



PROCESS OPTION 3
(BIOLOGICAL TREATMENT OF BLOWDOWN)

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-304
DATE MAY\92



	PROCESS OPTION 4 (FILTRATION OF BIOLOGICALLY TREATED BLOWDOWN)	ONTARIO MINISTRY OF ENVIRONMENT		BEAK DRAWING NO 91-5070-305 DATE MAY\ 92

Option 3: This configuration is shown in Drawing No. 304 and is exactly the same as the BAT 2-5 plant, minus the last two steps of ion exchange and effluent filtration.

Option 4: The Option 4 configuration in Drawing No. 305 is similar to the BAT 2-5 plant minus the ion exchange. A sand filter final polishing step is used in Option 4 instead of the pressure filter employed at the BAT 2-5 foundry.

8.1.4 Predicted Effluent Quality

Table 8.2 presents the predicted effluent quality for BAT 1 and BAT 2-5 as applied to the Ontario plants. A total final effluent discharge of 2 cubic metres per tonne of metal melted was used as the basis for the mass discharge predictions for BAT 2-5. This flow represents a net reduction of 97-98 percent compared to BAT 1 at 90 m^3/t final discharge although it is somewhat higher than the flow reported from Foundry No. 1. This flow number was selected based on best professional judgement using the available information.

Table 8.2 also presents VF(30) and VF(4) variability factors which are summarized in greater detail in Appendix 2. The origin of the variability factors for BAT 2-5 were discussed previously in Section 6.1.11.

The selection of 2 m^3/t melted excludes sanitary effluent as the BAT model plant does not treat and recycle its sanitary effluent with the process, cooling and storm water sources.

Table 8.3 compares the mass discharges of selected contaminants for the four Options as compared to the BAT 1 and the BAT 2-5 predictions at either extreme. For the most part the estimated discharges are not rigorously supportable using the approach to effluent predictions outlined in the MISA Issues Resolution Report. The data are best estimates and are presented for interest only.

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TABLE 8.2: PREDICTED PERFORMANCE OF BAT (WET PROCESSING SUB-SECTOR)

	Units	BAT 1 General Motors, St. Catharines				BAT 2-5 Foundry No. 1			
Flow Basis*	m³/t	90				2			
Parameter	**RMDL (mg/L)**	**Long-Term Average (mg/L)**	**Long-Term Average (g/t)**	**VF(30)**	**VF(4)**	**Long-Term Average (mg/L)**	**Long-Term Average (g/t)**	**VF(30)****	**VF(4)****
DOC	0.5	3.0	280	NA	1.5	NA	NA	NA	NA
BOD_5	5	NA	NA	NA	NA	0.5	1.0	1.5	2.5
Oil and Grease	1.0	1.8	160	1.3	1.8	0.10	0.20	1.8	3.2
TSS	5.0	15	1,450	2.1	3.8	0.88	1.8	1.4	2.2
Ammonia-N	0.25	0.56	52	NA	1.6	0.16	0.32	1.5	2.3
Total-P	0.10	0.082	7.1	NA	3.0	0.99	2.0	1.4	1.5
Aluminum	0.030	0.54	49	NA	2.1	0.003	0.006	NA	NA
Cadmium	0.002	0.0019	0.17	NA	1.4	0.001	0.002	NA	NA
Iron	0.020	0.67	61	NA	2.3	0.025	0.050	NA	NA
Copper	0.010	0.0057	0.51	NA	1.6	0.001	0.002	1.4	1.9
Lead	0.030	0.029	2.7	NA	1.7	0.003	0.006	1.3	1.8
Zinc	0.010	0.39	35	NA	2.0	0.059	0.12	1.4	1.4
Phenolics	0.002	0.051	4.3	1.5	2.2	0.002	0.004	2.7	5.2
Total Cyanide	0.005	0.005	0.43	NA	1.4	0.004	0.008	1.2	1.4
Acute Lethality									
• Rainbow Trout		Non-lethal (11 times out of 12)				Non-lethal			
• *Daphnia magna*		Non-lethal (9 times out of 12)				Non-lethal			

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* Excludes sanitary effluent.

** Higher value from Foundry No. 1 or Foundry No. 2.

NA = No data available.

TABLE 8.3: PREDICTED MASS DISCHARGES FOR BAT OPTIONS (WET PROCESSING SUB-SECTOR) (Long-Term Averages)

Parameter	Units	Best in Ontario	Option 1	Option 2	Option 3	Option 4	Best in World
Combined Flow Basis	m^3/t	90	45	45	2	2	2
Suspended Solids	g/t	1,450	1,030	1,020	30	5.2	1.8
Oil and Grease	g/t	160	92	87	0.32	0.32	0.20
Total Phosphorus	g/t	7.1	2.0	2.0	NA	2.0	2.0
Aluminum	g/t	49	32	20	NA	NA	0.006
Iron	g/t	61	27	27	NA	NA	0.050
Copper	g/t	0.51	0.30	0.30	0.02	0.02	0.002
Lead	g/t	2.7	0.23	0.006	0.06	0.06	0.006
Zinc	g/t	35	0.40	0.12	0.40	0.40	0.12
Phenolics	g/t	4.3	4.3	0.014	0.004	0.004	0.004
Cyanide	g/t	0.43	0.2	0.009	0.008	0.008	0.008
Toxicity							
• Rainbow Trout	% 96-h LC_{50}	Non-lethal (11/12)	NA	NA	NA	NA	Non-lethal
• *Daphnia magna*	% 48-h LC_{50}	Non-lethal (9/12)	NA	NA	NA	NA	Non-lethal

Effluent predictions for Option 1 were prepared by using the measured discharge in the storm and cooling flows at the BAT 1 plant (G.M. St. Catharines) and the concentration data cited by EPA as the basis for BPT for TSS, Oil and Grease, copper, lead and zinc in the chemically treated and settled process effluent blowdown (EPA, 1985).

The predicted final effluent quality for Option 2 combined the existing cooling and storm discharge at the BAT 1 plant with the discharge at the BAT 2-5 plant at 1 m^3/t for the process effluent component.

Predictions of effluent quality for Option 3 were the same as for Option 4 with a change in the concentration basis for TSS from 2.6 mg/L in Option 4 with the filter to 15 mg/L in Option 3 without a filter.

The effluent in Option 4 would differ from the effluent in the BAT 2-5 plant only in concentrations of metals affected by ion exchange. The concentrations of copper and lead were calculated on the assumption that ion exchange would remove 90 percent of these metals. A similar assumption for zinc would have been inappropriate as the estimated mass discharge would have been higher than for Option 1. The Option 1 discharge was used in this case.

8.2 Dry Processing Sub-Sector

8.2.1 BAT 1 (Best in Ontario)

Western Foundry and Canada Alloy are identified equally as the BAT 1 (Best in Ontario) plant. This can be seen by examining the discharge data for the six direct discharging plants in this sub-sector as presented in Table 8.4.

The two plants have similar direct discharge flows per tonne of metal melted (e.g., 3.3-4.8 m^3/t range). Oil & Grease is the only contaminant that the plants have

TABLE 8.4: SUMMARY OF ONTARIO DISCHARGES - DRY PROCESSING

Parameter	Units	Franklin Electric	Richmond Die	Chrysler Etobicoke	Western Foundry	Canada Alloy	Kubota
Flow (Direct Discharge)	m^3/t	644	175	22	4.8	3.3	12.9
Oil and Grease	mg/L	1.8	2.8	2.1	2.2/5.5	2.6	3.0
	g/t	1,160	480	46	11	9.8	39
DOC	mg/L	67.1	6.6	35.9	0.9/1.2	1.5	5.2
	g/t	48,100	1,120	763	3.9	5.2	67
Suspended Solids	mg/L	19.3	11.2	NA	NA/6.5	4.3	25.7
	g/t	14,900	2,000	NA	18	14	330
Aluminum	mg/L	0.16	0.08	0.12	0.071/0.18	0.04	0.41
	g/t	128	14	2.8	0.31	0.15	5.3
Copper	mg/L	NA	NA	0.022	0.009/0.010	0.012	0.018
	g/t	NA	NA	0.50	0.033	0.037	0.23
Zinc	mg/L	0.027	0.019	0.057	0.043/0.041	0.89	0.016
	g/t	19	3.5	1.2	0.12	3.3	0.21
Phenolics	mg/L	NA	NA	NA	0.069/0.006	NA	0.007
	g/t	NA	NA	NA	0.011	NA	0.09
Acute Lethality							
• Rainbow Trout	% 96-h LC_{50}	>100	>100	>100	>100	>100	>100
• *Daphnia magna*	% 48-h LC_{50}	>100(3/4)*	>100	>100	>100	>100(3/4)*	>100

NA = Not available.

* = Three of four tests were greater than 100 percent 48-h LC_{50}.

facilities to control and both discharges are in the range between 10 and 11 g/t of metal melted.

The control technologies associated with the BAT 1 plants are as follows:

1. Significant recycling of once-through cooling waters but not necessarily complete loop closure.
2. Oil/water separation equipment.

There is no process effluent treatment technology in use at the six Ontario plants beyond oil/water separation as the minor volumes of these wastes are either disposed of off site or discharged to sanitary sewers.

Table 8.5 shows the predicted effluent discharges for the BAT 1 (Best in Ontario) model. The flow, the contaminant discharge and the variability factors selected were the higher of the two numbers reported by Western Foundry and Canada alloy. In this manner, both facilities meet the BAT 1 criteria. Data for DOC, TSS, aluminum, copper and zinc are included in Table 8.5, even though the oil/water separation process associated with BAT 1 will not necessarily affect these materials. The mass discharges, however, will decrease as the net effluent flow is decreased through recycle and/or reduction in water use.

The most effective method by which Franklin and Richmond can meet the effluent standards for BAT 1 in Table 8.5 is to completely eliminate their process discharges. In both cases, this involves a few relatively simple modifications. It would be difficult for Richmond or Franklin to achieve the flow and oil and grease levels for BAT 1 without complete closure. At Chrysler, the difference between part or all of the effluent reduction to 4.8 m^3/t and zero is part or all of the cooling water use at air compressors.

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TABLE 8.5: PREDICTED PERFORMANCE OF BAT (DRY PROCESSING SUB-SECTOR)

	BAT 1 Western Foundry and Canada Alloy				**BAT 2-5 DuPage**
Flow (m^3/t)	4.8				0
	RMDL (mg/L)	**LTA (g/t) ⁽¹⁾**	**VF(30) ⁽¹⁾**	**VF(4) ⁽¹⁾**	
Oil and Grease	1.0	11	N/A	2.9	None
DOC	0.5	5.2	N/A	1.5	None
TSS	5.0	18	N/A	1.5	None
Aluminum	0.030	0.31	N/A	2.7	None
Copper	0.010	0.037	N/A	1.7	None
Zinc	0.010	3.3	N/A	3.8	None
Acute Lethality	% 96-hr LC_{50} (Rainbow Trout) - Non-Lethal % 48-hr LC_{50} (*Daphnia magna*) - Non-Lethal				

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(1) Long-Term Averages and VF's for each parameter are based on the higher of the two values reported at Western Foundry and Canada Alloy.

Following is a summary of the main changes at these plants to meet the BAT 1 target.

Franklin

- install a glycol cooling system to replace once-through cooling water in the main plant;
- replace cooling water with an air cooler at the compressor;
- install a closed glycol cooling system to cool recycled water at the casting machines; and
- re-route storm flows around the cooling pond.

Richmond

- install a non-evaporative cooling system (i.e., glycol or air coolers) to replace cooling water at the compressors;
- collect die cast heat exchanger and die cast machine cooling water in a new sump and recirculate the flow via a water to glycol heat exchange system; and
- contract disposal of decanted die cast sump water.

Chrysler

- convert the mill water tank partial-recycle loop to a full recycle by adding an evaporative cooling tower;
- some re-routing of cooling flows to the evaporative recycle process; and
- discharge minor blowdown volumes from the evaporative cooling loop to the sanitary sewer (by permission from Region).

The effluent quality at the Kubota plant differs from the BAT 1 standards mainly in water consumption per ton of metal melted.

Contaminant concentrations except for suspended solids are comparable to those at Western and Canada Alloy. Increasing the degree of recycle is the only technique demonstrated under the BAT 1 model which can be applied to achieve reductions in the contaminant loads.

The approach used as a basis for estimating costs to meet BAT 1 for this plant include the following:

- complete the conversion of air compressor cooling systems to air or glycol cooled to eliminate freshwater or cooling pond water requirements for compressors;
- install independent cooling loops for each of the furnaces (e.g., indirect cooling water to glycol and glycol to air systems), thus eliminating the need for cooling pond water for furnaces; and
- installing an oil/water separator for the small amount of process flow (e.g., mould wash and/or quench overflow) ahead of the cooling pond.

These changes at Kubota would reduce the total effluent discharge to about 5 m^3/t. The concentration of oil and grease would remain at or below the present concentration of 3 mg/L. This would reduce the mass discharge to about 14 g/t, which is close to the 11 g/t value in Table 8.4.

Mass discharges of other contaminants would decrease but quantitative predictions cannot be made.

8.2.2 BAT 2-5

A zero direct discharge is identified as the basis for BAT 2 through BAT 5 for this sub-sector as discussed in Section 6.2.

In practice this means the elimination of all once-through cooling water which currently discharges to storm sewers or directly to a surface water course.

In most cases the implementation of a zero discharge strategy will mean the discharge of small quantities of cooling system blowdowns (e.g., 1-2 m^3/t of metal poured) or process effluent to the local municipal sanitary sewer. Pre-treatment would be based on local sewer use bylaws and/or agreements signed with local municipal authorities. General practise in Ontario and elsewhere is that little or no treatment is required beyond oil/water separation.

Some plants may find it necessary to include pH adjustment and flocculation for metals removal as is the case with Chicago White Metal discussed in Section 6.2.

In the extreme, it may not be appropriate to discharge any process related liquid to the sanitary sewer in which case collection and transport for off-site disposal may be the only option. This could be for all process wastes generated as is the case at Franklin Electric; or, it could mean volume reduction via evaporation and condensate recycle to minimize disposal costs as is the case at DuPage Die Casting.

Implementation of BAT 2-5 for Richmond and Franklin would be identical to BAT 1 as a "zero discharge" plan was used for each.

Implementing BAT 2-5 at Chrysler would be the same plan as for BAT 1, plus the elimination of compressor cooling water discharges.

The costs for achieving "zero discharge" at Kubota, Western and Canada Alloy were estimated based on the following general approach:

- eliminate all once-through water use at compressors;
- installing additional heat exchange capacity for furnace cooling to handle peak production and summer heat loads;

- removing all process and cooling flows from plant storm or direct discharge sewers; and
- assuming that an agreement could be reached with the local municipal authority to accept small quantities of blowdown.

At Kubota, a centralized evaporative cooling tower was assumed to replace the function of the existing cooling pond in developing the cost estimate. The small quantities of direct contact process water from mould wash and quenching could be introduced to the recycle loop in this manner.

8.3 Haley Industries Sub-Sector

8.3.1 BAT 1 (Best in Ontario)

Haley Industries is a special case because of the unique nature of the effluents generated and is therefore in a sub-sector comprising one plant. The existing plant with its ongoing effluent improvement program is by definition the Best in Ontario.

8.3.2 BAT 2-5

A model process satisfying the BAT 2-5 criteria is proposed for Haley based on demonstrated treatment processes, but excluding reference to a specific casting facility. None was found.

Operating data from the treatment facility at Martin Marietta (e.g., Appendix 3) is used as support for the effectiveness of the proposed treatment steps. Although the effluent sources and characteristics at Martin Marietta are similar to those at Haley, it should be kept in mind that Martin Marietta is not a casting plant, nor does Martin Marietta operate wet dust collectors, SO_2 mould setting or significant chemical milling of magnesium components.

The main treatment technologies associated with this BAT are as follows:

1. Biological treatment of all sanitary effluents and industrial processing effluents which contain oxygen demanding substances or ammonia.
2. Silver removal from X-Ray processing effluents using electrolytic silver recovery and ion exchange ahead of biological treatment.
3. Chemical reduction of hexavelant chromium to the trivalent form.
4. Metal removal from process effluent using chemically assisted flocculation and coagulation.
5. Sand filtration of effluent following metal removal.
6. Air stripping of trace volatile organics present in the process effluents.
7. Carbon adsorption of stripped effluent to reduce residual dissolved organic carbon concentration ahead of ion exchange.
8. Ion exchange of effluent for selective removal of metals such as copper, lead, zinc, cadmium and silver.
9. Impoundment of final treated effluent until analyses are completed to ensure each batch meets the required standard prior to discharge.

8.3.3 Predicted Effluent Quality

Table 8.6 summarizes the predicted final effluent quality for the BAT 1 and the BAT 2-5 options. The predictions for BAT 2-5 are based on the long-term effluent as concentrations from Appendix 3, plus the flows monitored at Haley Industries during the MISA Monitoring program. Haley Industries already recycles process flows from dust collection and scrubbing equipment. Demonstrated opportunities to reduce effluent volume discharge by further recycle are limited.

Some of the predicted concentrations of the contaminants of interest are at or below the RMDLs. Nevertheless, the predicted effluent quality would still fall short of meeting several of the requirements of the existing Certificate of Approval. It is concluded that

TABLE 8.6: PREDICTED PERFORMANCE OF BAT (HALEY INDUSTRIES)

	Units	BAT 1 (Existing Plant)				BAT 2-5 (Best in World)			
Flow Basis	m^3/d	130				130			
Parameter	RMDL (mg/L)	Long-Term Average (mg/L)	Long-Term Average (g/t)	VF(30)	VF(4)	Long-Term* Average (mg/L)	Long-Term Average (g/t)	VF(30)	VF(4)
TSS	5.0	307	15,700	1.5	1.9	2.0	102	1.7	2.2
BOD$_5$	5.0	N/A	N/A	N/A	N/A	5.6	290	1.1	1.2
DOC	5.0	36	2,300	N/A	1.5	N/A	N/A	N/A	N/A
Oil and Grease	1.0	1.6	82	1.4	1.9	1.3	67	1.4	1.9
Ammonia-N	0.25	32	1,750	1.3	1.5	10.6	580	1.2	1.3
Total-P	0.10	2.0	130	N/A	4.0	0.21	14	N/A	N/A
Total Cyanide	0.005	1.0	75	N/A	1.7	0.015	1	1.6	2.2
Fluoride	0.10	30	1,680	1.3	1.4	N/A	N/A	N/A	N/A
Aluminum	0.030	2.2	130	1.5	2.0	0.19	11	1.6	2.5
Iron	0.020	408	20,000	3.5	5.9	N/A	N/A	N/A	N/A
Zinc	0.010	0.85	49	1.5	2.1	0.062	3.6	1.3	1.6
Cadmium	0.002	0.0059	0.37	1.5	1.9	<0.0002	<0.01	1.2	1.5
Copper	0.010	0.625	34	1.4	1.8	0.011	0.60	1.5	2.0
Lead	0.030	0.064	3.4	1.4	1.8	0.003	0.16	1.2	1.6
Silver	0.030	0.40	21	1.6	1.9	<0.0002	<0.01	1.4	2.2
Phenolics	0.002	0.044	1.5	1.7	2.3	N/A	N/A	N/A	N/A
Acute Lethality									
• Rainbow Trout	% 96-h LC$_{50}$	9/10 Lethal				Non-lethal			
• *Daphnia magna*	% 48-H LC$_{50}$	3/5 Lethal				Non-lethal			

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* Appendix 3 for reference on predicted effluent concentrations.

some elements of the existing Certificate of Approval have not been demonstrated as achievable based on the Ministry of Environment's definition of Best Available Technology.

8.4 Virtual Elimination/Zero Discharge

8.4.1 Definitions

The concepts of "zero discharge" and "virtual elimination" have been the subject of much discussion and some misunderstanding. The following definitions of these terms have been extracted from a document published by the International Joint Commission (IJC) on virtual elimination of persistent toxics (IJC, 1991).

Virtual elimination is a strategy to be implemented to eliminate to the extent possible, persistent toxic substances from the environment. This plan involves prevention in some cases and treatment or remediation in others. Since it will be impossible to recover all persistent toxics that have already been released, the term "virtual" has been used.

The concept of "zero discharge" was developed as part of the "Virtual Elimination" strategy. In this context, "zero discharge" refers to the elimination of all persistent toxic substances from effluent discharging directly or indirectly to the environment. In other words, there will be no further addition of persistent toxics to the environment.

The MOE has indicated separately that volume reduction is also a desirable action.

Sanitary effluent, non-process storm runoff and cooling water which has not been in contact with the process and has received no chemical supplements do not contain process contaminants. It follows that these effluent sources are excluded from the definition of zero discharge.

8.4.2 Progress Toward Effluent Reduction

The practises which are moving the casting industry toward Effluent Reduction include the following three general elements:

1. Replace wet processes with equivalent dry processes.
2. Recycle process effluents and discharge minimum possible quantities of blowdowns for dissolved solids control.
3. Volume reduction of segregated liquid wastes and blowdown by evaporation and/or off-site disposal of liquid residues.

These general practises are applicable to all industry sub-sectors. The Dry Processing Sub-Sector creates the least amount of process effluent and has already demonstrated that closed cycle operation is achievable. The other sub-sectors have made significant progress toward this objective but there are insufficient data for closed loop operation to be considered a proven technology as defined by the MOE MISA Program.

Replacement of Wet Processes

Most dust collection requirements in foundries can be served by dry collector systems instead of wet systems. It is much easier to adopt a dry dust collection strategy at a greenfield facility as opposed to retrofitting an existing plant. Individual wet collector units have been replaced with dry collectors at many plants including Ford and General Motors in Ontario. The net effect on water consumption may be minor in such cases if the dust is handled via the existing wet sluicing system which is often the case.

The transfer of water soluble, volatile contaminants from scrubbing effluents to the air is a technical problem that will exist in some dust collection situations. Phenolic vapour carrythrough of baghouse fabrics in sand milling dust collection facilities is an example.

Dry slagging has successfully replaced wet slag quenching at Canada Pipe in Hamilton and there may be similar opportunities at other plants. Once again, this is much more likely to be attractive at greenfield facilities.

Recycle of Process Effluents

Most process effluents can be recycled or at least the total make-up volume of fresh water can be rigidly controlled to reduce the net liquid discharge/residue from a single process to a very small quantity. Recycling effluent from wet dust collection, melting furnace emission scrubbing, slag quenching, dust/slag sluicing, and SO_2 scrubbers are the most common examples discussed in this report. All of these recycle processes to date still require at least a small quantity of liquid blowdown to maintain control of dissolved solids in the recycle systems which in turn affects the potential for scaling and corrosion. The minimum quantity of blowdown is usually 2 percent or less of the recirculating flow.

Blowdown Volume Reduction/Disposal

The total volume of segregated liquid process effluents and residues may be sufficiently small at some casting facilities to allow economic contract hauling for off-site disposal. This was the situation at Franklin Electric. In most cases, there is a need for further volume reduction before the volumes of residues are small enough to permit economic contract disposal. In the broad sense, contract disposal can be defined as a direct contract for hauling off-site or as a contract with a municipal sewer authority for discharge of small volumes of residues to the sanitary sewer.

Evaporation is the principal technique used for volume reduction although other methods such as reverse osmosis at the Mitsubishi plant in Kobe, Japan are being used. Evaporation is being used in several different ways. Canada Pipe in Hamilton eliminates some of its process blowdown by means of cooling/quenching sprays to its centrifugal pipe casting machines. The DuPage plant has adopted the use of a dedicated evaporator to reduce total residue volume. Condensate is sufficiently clean to replace the limited freshwater requirements of the die cast lubricant formulation. The Crowe Foundry in Cambridge evaporates some of its process blowdown by using it as part of the water make-up to their sand mulling operation.

The water that leaves the plants with dust collector and cupola scrubber sludge is another method by which dissolved solids in the process blowdowns are purged from the recycle process water loops.

9.0 IMPLEMENTATION OF BAT AT ONTARIO PLANTS

9.1 Estimated Capital Costs

9.1.1 Estimating Procedures

An estimate was prepared of the capital cost to implement each of the defined BAT's at the nine remaining direct discharging plants in Ontario.

The estimates were prepared using budget estimates of equipment items received from vendors as well as library cost data available within Beak Engineering. Major equipment items were identified and approximate sizes or capacities specified and plant layouts and site plans were consulted to determine probable locations for major structures. The degree of process and facility definition and the degree of site detail available for this exercise was consistent with producing an estimate accuracy of +20-30 to -20 percent.

Following is a breakdown of the elements of each cost component as presented in the summary tables. This summary format follows the outline prescribed by the MOE's Fiscal Planning and Economic Analysis Branch (formerly Policy and Planning Branch).

(a)	Engineering:	12 percent of b+c+d.
(b)	Equipment/Materials:	Cost of major mechanical and electrical items.
(c)	Installation:	Piping, instrumentation, electrical and equipment installation, including labour.
(d)	Facilities/Structures:	Buildings, tankage, paving and miscellaneous structures.
(e)	Land:	Purchase cost.
(f)	Other:	Indirect costs excluding engineering (30 percent of b+c+d).
Total:		Sum of a+b+c+d+e+f.

All costs are based on January dollars, 1992.

9.1.2 Cost Summary

The estimated costs to implement the BAT options at the two plants in the wet processing sub-sector are tabulated in Table 9.1.

This includes estimates for the four "Options" at both Ford and General Motors even though these are not technically defined as BAT's 1 through 5. The estimate of $920,000 to meet BAT 1 at the Ford plant was based on the assumption that partial biological treatment would be needed for a portion of the process flow (e.g., muller/core room dust collection) to reduce phenol discharges. A budget was also assumed for optimizing the existing chemical flocculation and coagulation process ahead of the primary clarifiers to improve metal and TSS removal.

The estimated costs for BAT 1 at the dry processing plants and for BAT 2-5 for both the dry processing and for the Haley sub-sectors are presented in Table 9.2. The estimates to meet BAT 1 at Richmond and Franklin were based on converting the compressor, furnace and casting machine cooling systems to completely closed glycol based processes or to evaporative cooling towers with blowdown to the sanitary sewer. This would convert both plants to zero direct discharge facilities. No further cost would be required at these plants to meet the BAT 2-5 process.

Work required to achieve BAT 1 at Chrysler and Kubota included modifying the partial recycle cooling systems at both plants into closed glycol or evaporative processes, plus several other minor changes as described in Section 8.2.1.

Estimates for BAT 2-5 for the remaining three plants in the dry processing sub-sector are also based on converting the cooling water systems to either completely closed processes or to evaporative cooling with blowdown to the sanitary sewer. The furnace cooling loops at Western Foundry are glycol based and the glycol would be flushed into the sanitary sewer

TABLE 9.1:

ESTIMATED CAPITAL COSTS FOR BAT
(Wet Processing Sub-Sector in $ x 1,000)

Item	Best in Ontario (BAT 1)	Option 1	Option 2	Option 3	Option 4	Best in World (BAT 2-5)
General Motors						
• Engineering and Design		1,000	1,460	1,590	2,070	3,220
• Equipment/Materials		3,750	5,250	5,800	9,150	14,150
• Installation		3,800	5,050	5,350	6,000	8,730
• Facilities and Structures		750	1,400	1,600	2,100	3,950
• Land		0	500	500	500	500
• Other	—	2,490	3,510	3,830	5,180	8,050
Total ($ x 1,000)	**0**	**11,790**	**17,170**	**18,670**	**25,000**	**38,600**
Ford						
• Engineering and Design	80	800	1,070	1,250	1,510	2,220
• Equipment/Materials	200	2,820	3,900	4,420	6,020	7,850
• Installation	250	3,300	4,050	4,600	4,880	7,260
• Facilities and Structures	200	450	930	1,430	1,680	3,430
• Land	0	0	0	0	0	0
• Other	190	1,970	2,660	3,140	3,770	5,550
Total ($ x 1,000)	**920**	**9,340**	**12,610**	**14,840**	**17,860**	**26,310**

TABLE 9.2:

ESTIMATED CAPITAL COSTS FOR BAT
(Dry Processing Sub-Sector and Haley in $ x 1,000)

BAT Option/Plant	Kubota	Canada Alloy	Western Foundry	Franklin Electric	Richmond Die Casting	Chrysler	Haley
Best in Ontario (BAT 1)							
• Engineering and Design	85			25	34	48	
• Equipment and Materials	250			85	80	169	
• Installation	350			80	170	200	
• Facilities and Structures	100			0	30	40	
• Land	0			0	0	0	
• Other	205	—	—	50	86	123	—
Total ($ x 1,000)	**990**	**0**	**0**	**240**	**400**	**580**	**0**
BAT 2-5							
• Engineering and Design	120	30	66	25	34	64	240
• Equipment and Materials	300	100	200	85	80	218	990
• Installation	550	150	300	120	170	262	850
• Facilities and Structures	150	0	50	0	30	50	150
• Land	0	0	0	0	0	0	0
• Other	300	70	164	60	86	156	600
Total ($ x 1,000)	**1,420**	**350**	**780**	**290**	**400**	**750**	**2,830**

in the event of an emergency situation during a power outage or a failure in the cooling system when city water would be automatically introduced. An allowance was made for an emergency dump tank to collect the glycol coolant during the infrequent emergency cooling events. This could be returned to the cooling loop at a later date or gradually bled to the sanitary sewer.

Costs for the model BAT process described in Section 8.3.2 for Haley Industries include an expanded on-site laboratory to accommodate the 24-hour turn-around needed for the batch testing and discharge operating philosophy which is inherent in the process. The South Process Sewer at Haley is presently mainly a storm sewer. The MISA Monitoring program demonstrated that storm flows in this sewer contain significant contaminants. An allowance was therefore made to include a collection tank and pumpout for the initial flow through this sewer for storm events. The pumping system would bleed the storm flow into the BAT 2-5 process train.

9.2 Estimated Costs for Operating and Maintenance

Table 9.3 presents the estimated costs for operating and maintenance for all of the BAT scenarios for the Wet Processing Sub-Sector. The costs for the Dry Processing Sub-Sector and Haley are summarized in Table 9.4. Unit costs used as a basis for these estimates are shown in Table 9.5.

The items included under the general heading of Materials comprise chemicals, carbon supplies, resins, as well as any reduction in annual cost that would accrue as a result of reductions in water usage. The net negative cost for this item at several of the plants is indicative of a potential savings for reducing the purchase of water. In a few cases this savings would appear to be sufficient to provide a positive, although not necessarily attractive, return on the cost of implementing BAT.

TABLE 9.3: ESTIMATED ADDITIONAL OPERATING AND MAINTENANCE COSTS
(Wet Processing Sub-Sector - $ x 1,000/yr)

Item	Best in Ontario (BAT 1)	Option 1	Option 2	Option 3	Option 4	Best in World (BAT 2-5)
General Motors						
• Energy		200	230	340	340	360
• Materials		0	290	180	180	340
• Labour		0	450	290	290	450
• Maintenance	—	290	330	430	530	670
Total ($ x 1,000/yr)	**0**	**490**	**1,300**	**1,240**	**1,340**	**1,820**
Ford						
• Energy	10	70	90	90	90	100
• Materials	30	20	120	30	30	160
• Labour	20	0	410	270	270	410
• Maintenance	10	150	180	230	280	330
Total ($ x 1,000/yr)	**70**	**240**	**800**	**620**	**670**	**1,000**

TABLE 9.4: ESTIMATED ADDITIONAL OPERATING AND MAINTENANCE COSTS
(Dry Processing Sub-Sector and Haley - $1,000/Year)

BAT Option/Plant	Kubota	Canada Alloy	Western Foundry	Franklin Electric	Richmond Die	Chrysler	Haley
Best in Ontario (BAT 1)							
• Energy Costs	12			0.6	2.0	7	
• Materials	(12)			0.2	0.5	(146)	
• Labour	4			0.6	0.7	4	
• Maintenance	16	—	—	2.6	2.8	9	—
Totals ($ x 1,000/Year)	**20**	**0**	**0**	**4.0**	**6.0**	**(126)**	**0**
Best in World (BAT 2-5)							
• Energy Costs	26	1	8	0.6	2.0	10	12
• Materials	(15)	(19)	(80)	0.2	0.5	(200)	15
• Labour	4	2	4	0.6	0.7	4	160
• Maintenance	16	3	6	2.6	2.8	10	30
Totals ($ x 1,000/Year)	**31**	**(13)**	**(62)**	**4.0**	**6.0**	**(176)**	**217**

TABLE 9.5: UNIT COSTS FOR OPERATING COST ESTIMATES

Item	Units	Cost
Chemicals		
• Calcium Triple Super Phosphate (46% P_2O_5)	$/t	400
• Perlite	$/t	200
• Lime (100 Hydrated Lime, Bulk)	$/t	200
• Alum	$/t 47% Liq.	110
• Polymer	$/kg	5
• Hydrogen Peroxide (35% @ 227 kg Drum)	$/kg H_2O_2	2
• Sodium Hydroxide (50% @ 7.6 m^3 Delivery)	$/t NaOH	700
• Sulphuric Acid (66 Baumé @ 100 kg Drum)	$/t Liq.	300
Materials and Services		
• Powdered Activated Carbon	$/t	1,500
• Granular Activated Carbon	$/t	1,500
• Rohm & Haas IRC 718 Ion Exchange Resin	$/$m^3$	460
• Power	$/kWh	0.05-0.07
• Ion Exchange Regenerant Chemicals	$/$m^3$ Resin•y	1,400
• Cooling Tower Service Contracts (Chemicals)	$/Million BTU (Operating Transfer)	0.25
• Municipal Water Cost	$/$m^3$	0.06-0.8
• Contract Disposal of Oily Waste	$/$m^3$	10
Labour		
• Operators	$/h	20-35
• Laboratory Staff	$/h	25
• Supervisory	$/h	35
• Operating Day	Days/yr	250-300
Equipment Maintenance		
• Annual Cost (Materials plus Labour)	Percent of Equipment Cost	3

The existing costs for maintenance at Richmond Die Casting include the cost of contract disposal of 0.4 m^3/d of decant flow from the die cast sump oil/water separator. It was assumed that this material contains mainly glycol (e.g., BOD_5) and surfactant which would permit discharging to a municipal water pollution control plant. Installing an evaporator for volume reduction would be the logical alternative.

10.0 BEST MANAGEMENT PRACTICES

10.1 Introduction

Best Management Practices (BMP) are those practices, functions or modifications that can or should be implemented by a facility to reduce or eliminate the volume or toxicity of wastewater generated. The inclusion of a process or practice as a BMP means it is not considered in the development of a regulation, but has been identified as a suggested means for improvement in the operation. Improvement could be defined as a method to decrease water use, to decrease the potential for waste generation, or to reduce the costs of environmental management.

The following BMPs have all in some form or another been implemented full-scale at a foundry in the United States or elsewhere in the world. While by no means exhaustive, these measures have been shown to have a significant impact on the quantity and quality of wastes and/or wastewater generated.

10.2 Dry Dust Collection

Baghouses, cartridge filters, centrifugal separators and electrostatic precipitators in place of wet dust collectors, have been proven effective in a number of foundry operations. The obvious advantage of these unit operations is that very little or no wastewater is generated from the process. Economic studies performed by some foundries have shown that dry processes can be economically superior to wet collectors. These two factors have caused some foundries, particularly in the United States and Germany, to replace wet collectors with dry collectors.

There can be problems to overcome with dry collectors. One disadvantage is the handling of the collected dry material. Some foundries are sluicing the dry collected dust with water. The water use is reduced over what a wet collector would use, but it is not eliminated.

Also, plugging has been a concern. Pneumatic conveying of the dust is costly and not currently proven in foundry applications.

Effectiveness of the removal of smaller particulates, fumes, and non-particulate pollutants can be an issue. In the United States, this is especially important in light of the recently enacted Clean Air Act which concerns with the release of air toxics. Another problem with dry collectors is heat. Without cooling the air stream prior to dry collection, particularly in high temperature areas such as iron shakeout, deterioration or destruction of the filter media can result. Dust explosions can also occur.

10.3 Dry Emission Controls for Cupolas

Application of dry treatment of off-gasses from melting furnaces is generally more difficult than the application of the technology for dust collectors. The primary obstacles are heat and volume of air to be treated. While dry scrubbing technology has been used in relatively small melting facilities, its relevance for large scale operations is questionable. Cooling of the gas stream can be accomplished by jacketing (using either water or a coolant solution), direct spray, and other methods. One method of indirect cooling is using a recuperative cupola to collect heat from the waste gasses, which simultaneously results in cooling the gas.

10.4 Raw Material Storage

Where feasible, raw material such as sand, scrap, coal, and other raw materials should be stored under roof or in a bunker to prevent contamination of stormwater. Alternately, the stormwater from similar storage areas which are uncovered could be impounded and bled into the plant's effluent treatment system. An impermeable base should be provided for the stored material to prevent stormwater infiltration to the soil and groundwater.

10.5 Dry Slag Quench

In grey iron foundries, slag sluicing and slag quench using water is a common operation. In some smaller foundries, however, dry slag quench is practised. This commonly takes the form of a refractory lined box to capture the slag, followed by air cooling and solidification. Some foundries have found the slag to contain enough residual iron that it is economically attractive to recycle some of the slag back to melting for metal recovery.

10.6 Chemical and Raw Materials Use

There are a number of modifications to the processes and chemicals used in production which will reduce the volume and toxicity of wastewater. However, each production facility is unique in its makeup and it is difficult to identify universal methods to achieve reduction. In plants that produce cores, resins and curing agents should be evaluated not only for productive value but also for environmental impact. Recently, chemical producers have been marketing low phenolic resins that may have some benefit. Use of foam or wax in place of sand is continually being evaluated, as is no-core moulding. The advantages of cold box versus hot box versus warm box coremaking is also a target for evaluation.

Scrap should be tested and standards established for the content of spurious metals, particularly lead and zinc.

In die casting, the use of alternative formulations of die and shot lubes, as well as hydraulic oils that are more amenable to biological oxidation is advantageous in that they are more easily treated than conventional petroleum-based materials.

10.7 Dry Cleanup

The use of hoses and water to cleanup spills and leakage around die casting machines can be reduced by dry collection and cleanup. This can be accomplished by dry adsorbents, but this generates a solid waste for disposal. Another alternative is to collect the released coolants or lubes and either process and reuse on-site, or send off-site for cleanup and reuse.

10.8 Internal Multiple Use and Reuse

In many cases, water that is used in one process can be used in other processes prior to wastage. A simple example would be the use of waste non-contact cooling water being used for dust collector or melting furnace scrubbing as is presently practised by General Motors and Ford in Ontario. In some cases, the use of water can be "stacked", similar to the countercurrent rinsing methods used by metal plating shops. As an example, waste cooling water from a cupola could be used in a secondary venturi scrubber, followed by the primary scrubber, followed by slag quench. In this way, each aliquot of water is used to its maximum for removal of pollutants and cooling. In terms of direct re-use, a secondary cyclone for the wastewater from a dust collector could yield a concentrated underflow stream and a relatively clean overflow that could be reused in the dust collector.

While not all of these operations have been implemented full-scale, they are examples of the type of evaluations that facilities could undertake to improve the "usefulness" of water.

10.9 Creation of a Spills Management Program

Creation, implementation, and continual compliance with a spills management program will reduce shock loads to a treatment system and enhance the performance of that system. The program should have several aspects. It should include evaluation of the sources of potential spills, the impact of individual spills, preventative measures that can be taken to mitigate or prevent such spills, a response plan, and training for personnel on how to respond to a spill. The plan should be subject to annual review, and an audit procedure should be in place to regularly update and refine the plan. Another aspect of the program should be to establish a Quality Assurance (QA) review procedure to ensure that the installation of new facilities or processes have been evaluated with respect to environmental impact.

GLOSSARY

BAT - Best Available Technology (defined by MOE as a process or collection of processes operating at a plant somewhere in the world for which there are long-term performance data)

BMP - Best Management Practices

BOD_5 - 5-Day Biochemical Oxygen Demand

BPJ - Best Professional Judgement

BPT - Best Practicable Technology

C of A - Certificate of Approval

Cr - Chromium

d - Day

DOC - Dissolved Organic Carbon

EPA - United States Environmental Protection Agency

IJC - International Joint Commission

JTC - Joint Technical Committee for the Metal Casting Sector

L - Litre

LOEC - Lowest-Observed-Effect-Concentration in a sub-lethal bioassay

m^3 - Cubic metre

mg - Milligram

MENVIQ - Ministry of Environment of Quebec

MISA - Municipal and Industry Strategy for Abatement

MOE - Ontario Ministry of the Environment

N/A - Not available/applicable

NH_3-N - Ammonia plus ammonium nitrogen

NO_2-N - Nitrite nitrogen

NO_3-N - Nitrate nitrogen

NOEC - No-Observed-Effect-Concentration in a sub-lethal bioassay

NPDES - National Pollutant Discharge Elimination System

NTIS - National Technical Information Service

O/G - Oil and Grease

PAC - Powdered Activated Carbon

RBC - Rotating Biological Contactor

RMDL - Regulation Method Detection Limit

t - 1,000 kilograms

tonne - Metric tonne (1,000 kilograms)

TCA - Trichloroethane

TCE - Trichloroethylene

TSP - Calcium triple super phosphate

TSS - Total Suspended Solids

VF(30) - 30-Day Variability Factor (MOE, 1991)

VF(4) - 4-Day Variability Factor (MOE, 1991)

VF(1) - 1-Day Variability Factor (MOE, 1991)

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APPENDIX 1

Sample BAT Candidate Plant Questionnaire

Date: September 13, 1991

FOUNDRY WASTEWATER TREATMENT SURVEY

(Add additional sheets as necessary)

A. GENERAL

Date: ______________________

Plant Name: ____

Plant Location: ____

Contact Name: ________________ Title: ________________________

Telephone No.: ________________ Fax No.: _____________________

General Description of Facility: (Number and type of plants in complex, total site area, water source, primary products). One or two sentences.

____

____

B. PROCESS AND FACILITY DATA

	Plant 1	Plant 2
Year Original Built	________	________
Metals (Primary Metals Melted):	________	________
	________	________
	________	________
Melting Furnace Types, Number, and Capacity	________	________
	________	________
	________	________
Melting: Max Capacity (metric tons/hr)	________	________
Current Production (metric tons/ hr ± 10%)	________	________
Molding Methods (green sand, die, etc.)	________	________
	________	________
	________	________
	________	________

PROCESS AND FACILITY DATA (Cont'd)

	Plant 1	Plant 2
Core-Making Method(s)(shell, cold box, hot box, etc.)		
Please check off the operations present at your facility:		
Casting Cleaning (water based)		
Casting Quench (water based)		
Dust Collector Scrubbers (wet)		
Grinding Scrubber (wet)		
Investment Casting		
Melting Furnace Scrubber (wet)		
Mold Cooling (water based)		
Die Casting Operations		
Slag Quench (water based)		
Wet Sand Reclamation		
Is Metal Purged (if so, with what?)		
Other:______________________		

	Melting	Finishing	Other
Operations:			
Days/Week			
Hours/Day			

C. RAW MATERIALS

	Plant 1	**Plant 2**
Primary Charge Materials to Melting Unit, (metric tons/week, or as % of total melt)		
Type and Quantity (metric tons/wk) of Sand(s) used, if any		
Identify Main Types of Materials (Binders, Die, Lubes, Shot Lubes, Tip Lubes, Hydraulic Fluid, etc.) for Mold/Core/Casting Production in Metric Tons or Cubic Meters Used/Week		
Auxiliary Materials (Casting Lubes, etc.)		
Wet Sand Reclamation, metric tons/wk (if applicable)		
Sand Recycling: (approximate percent of total)	%	%

D. FACILITY SCHEMATIC

Provide a simple block diagram including major production processing operations.

APPENDIX 2

Variability Factors for Effluent Concentrations

TABLE A2.1: VARIABILITY FACTORS FOR CONCENTRATIONS (Total Combined Outfall)

Parameter/Plant	Foundry No. 1 BAT 2-5			Foundry No. 2			G.M. St. Catharines BAT 1		
	VF(30)	VF(4)	VF(1)	VF(30)	VF(4)	VF(1)	VF(30)	VF(4)	VF(1)
Outfall I.D.		102			002			1000	
Dissolved Organic Carbon	NA	NA	NA	NA	NA	NA	NA	1.5	2.3
BOD_5	NA	NA	1.0	1.5	2.5	7.2	NA	NA	NA
O&G	NA	NA	1.0	1.8	3.2	11.3	1.3	1.8	6.6
TSS	1.4	2.2	5.7	1.4	1.9	5.0	2.1	3.8	23.8
Ammonia-N	1.2	1.4	2.5	1.5	2.3	8.0	NA	1.6	3.5
Tot-P	1.4	1.5	1.7	NA	NA	NA	NA	3.0	9.7
Aluminum	NA	NA	NA	NA	NA	NA	NA	2.1	9.9
Cadmium	NA	NA	NA	NA	NA	NA	NA	1.4	2.8
Iron	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	NA	NA	1.0	1.4	1.9	4.0	NA	1.6	3.4
Lead	NA	NA	1.0	1.3	1.8	4.1	NA	1.7	3.9
Zinc	1.4	1.4	1.7	1.2	1.4	2.4	NA	2.0	9.8
Phenolics (4AAP)	1.7	2.0	3.0	2.7	5.2	38	1.5	2.2	7.1
Cyanide	1.2	1.4	2.3	NA	NA	NA	NA	1.4	2.8

NA = Not Available.
VF(30) = 30-Day Variability Factor.
VF(4) = 4-Day Variability Factor.
VF(1) = 1-Day Variability Factor.

TABLE A2.2: VARIABILITY FACTORS FOR CONCENTRATIONS (Total Combined Outfall)

Parameter/Plant	Foundry No. 4			John Deere		
	VF(30)	**VF(4)**	**VF(1)**	**VF(30)**	**VF(4)**	**VF(1)**
Outfall I.D.		001			008 (Process Only)	
Dissolved Organic Carbon	NA	NA	NA	NA	NA	NA
BOD_5	NA	NA	NA	NA	NA	NA
O&G	1.3	1.7	3.0	1.4	2.0	4.9
TSS	1.3	1.6	3.5	1.4	2.1	5.7
Ammonia-N	NA	NA	NA	NA	NA	NA
Tot-P	NA	NA	NA	NA	NA	NA
Aluminum	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	NA	NA	NA	NA
Iron	NA	NA	NA	NA	NA	NA
Copper	NA	NA	NA	2.0	2.0	4.3
Lead	2.1	3.2	12	2.3	2.1	4.0
Zinc	1.9	2.2	6.1	2.1	3.0	9.4
Phenolics (4AAP)	1.3	1.6	2.8	1.6	2.6	11
Cyanide	NA	NA	NA	NA	NA	NA
Fluoride	NA	NA	NA	NA	NA	NA

NA = Not Available.
VF(30) = 30-Day Variability Factor.
VF(4) = 4-Day Variability Factor.
VF(1) = 1-Day Variability Factor.

TABLE A2.3: VARIABILITY FACTORS FOR CONCENTRATIONS

	Waupaca			Chrysler Indianapolis		
Parameter/Plant	**VF(30)**	**VF(4)**	**VF(1)**	**VF(30)**	**VF(4)**	**VF(1)**
Outfall I.D.		001			Process Outfall	
Dissolved Organic Carbon	NA	NA	NA			
BOD_5	NA	NA	NA	NA	NA	NA
O&G	2.2	3.2	10	2.2	3.1	9.8
TSS	1.4	1.9	4.3	NA	NA	NA
Ammonia-N	NA	NA	NA	NA	NA	NA
Tot-P	NA	NA	NA	NA	NA	NA
Aluminum	NA	NA	NA	NA	NA	NA
Cadmium	NA	NA	1.0	NA	NA	1.0
Iron	NA	NA	NA	NA	NA	NA
Copper	1.8	2.4	6.6	1.3	1.6	3.2
Lead	NA	NA	1.0	1.3	1.6	4.1
Zinc	NA	NA	1.0	1.5	2.0	5.0
Phenolics (4AAP)	1.5	2.6	7.4	2.6	3.8	13
Cyanide	1.8	3.4	11	NA	NA	NA
Chromium (+6)	1.6	2.7	9.7	NA	NA	NA

NA = Not Available.
VF(30) = 30-Day Variability Factor.
VF(4) = 4-Day Variability Factor.
VF(1) = 1-Day Variability Factor.

TABLE A2.4: VARIABILITY FACTORS FOR CONCENTRATIONS (Total Combined Outfalls)

	Martin Marietta BAT 2-5 (for Haley)			Haley Industries BAT 1 (for Haley)		
Parameter/Plant	VF(30)	VF(4)	VF(1)	VF(30)	VF(4)	VF(1)
Outfall I.D.		001			Process Outfall	
BOD_5	1.1	1.2	1.8	NA	NA	NA
Dissolved Organic Carbon	NA	NA	NA	NA	1.5	3.4
O&G	1.4	1.9	3.6	1.4	1.9	7.0
TSS	1.7	2.2	6.1	1.5	1.9	6.4
Nitrate+Nitrite-N	NA	NA	NA	NA	3.7	13
Ammonia-N	1.2	1.3	1.8	1.3	1.5	3.0
Tot-P	NA	NA	NA	NA	4.0	26
Total Cyanide	1.6	2.2	5.3	NA	1.7	3.6
Fluoride	1.2	1.3	2.0	1.3	1.4	3.3
Aluminum	1.6	2.5	7.2	1.5	2.0	7.6
Iron	NA	NA	NA	3.5	5.9	44
Zinc	1.3	1.6	2.7	1.5	2.1	9.6
Cadmium	1.2	1.5	3.0	1.5	1.9	5.5
Copper	1.5	2.0	5.2	1.4	1.8	5.8
Lead	1.2	1.6	5.9	1.4	1.8	5.4
Nickel	1.6	1.9	6.3	2.0	2.6	15
Molybdenum	NA	NA	NA	1.3	1.6	4.4
Silver	1.4	2.2	3.6	1.6	1.9	4.7
Phenolics (4AAP)	NA	NA	NA	1.7	2.3	6.6
Bis(2-ethylhexyl)phthalate	NA	NA	1.0	NA	2.2	6.2

NA = Not Available.
VF(30) = 30-Day Variability Factor.
VF(4) = 4-Day Variability Factor.
VF(1) = 1-Day Variability Factor.

APPENDIX 3

Martin Marietta

APPENDIX 3: MARTIN MARIETTA

Facility

Martin Marietta Astronautics Group operates an aerospace manufacturing and research complex in Waterton, Colorado which is about 30 kilometres from Denver. The Titan launch vehicle is the facility's main product beyond the defense plus research and development activities.

The complex occupies approximately 2,100 hectares of land in the foothills, it contains several major production and research buildings and there are about 5,000 employees.

A variety of domestic and industrial processing effluent sources, including some contaminated groundwater, are collected in a series of seventeen lift stations, treated in a centralized effluent treatment process and discharged into a headwater feeder of the South Platte River. The stream is a "Gold Medal" trout stream and is a kilometre or two upstream of the Chatfield Reservoir which supplies drinking water to the city of Denver.

The Colorado Department of Health has jurisdiction over the discharge quality and has developed demanding limits owing to the importance of the water course.

As a defence contractor Martin Marietta operates as a "rate base" business as opposed to the open competitive market in which most casting plants operate. The term "rate base" is used to describe businesses whose prices are regulated by government agencies based on an allowed profit margin calculated as a percentage of the cost of production. To some degree this can mean that the higher the cost, the higher the margin. This concept should be kept in mind when considering the complex and costly effluent treatment works at this site.

Effluent Sources and Characteristics

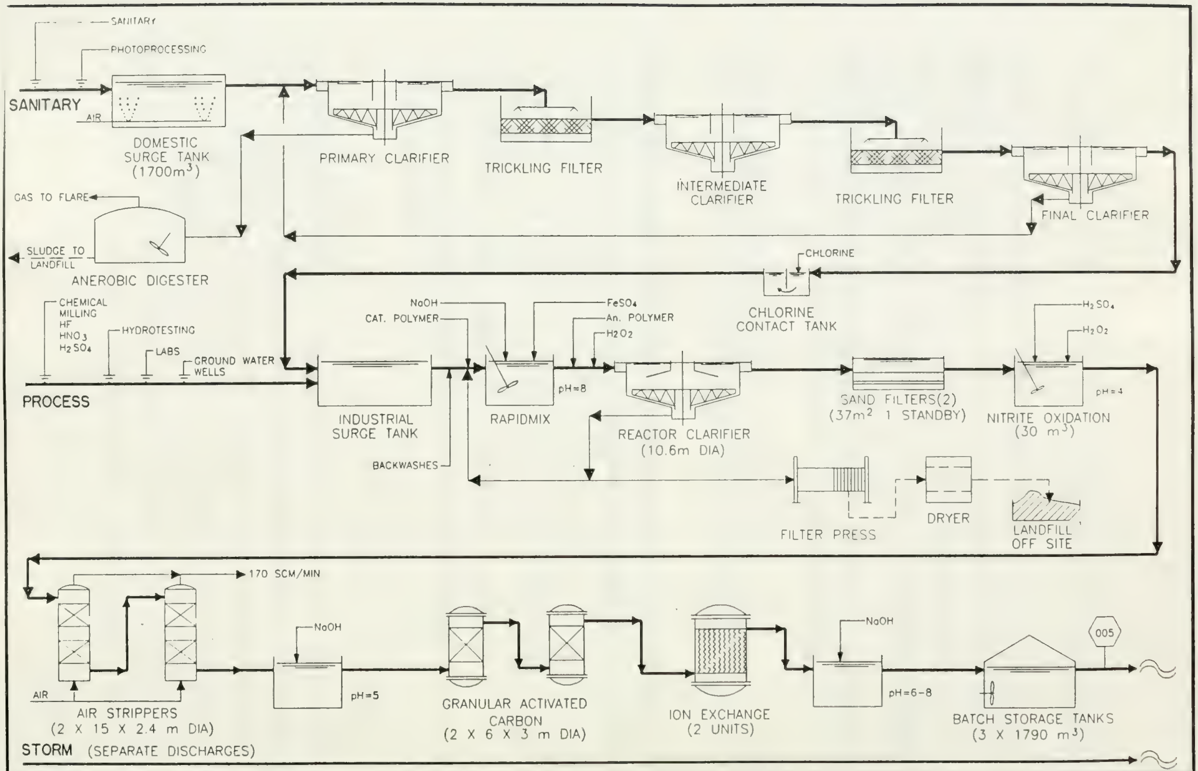
The total flow of raw wastewater averages 1,500 m^3/d and comprises about 60 percent domestic origin and 40 percent industrial in separate collection systems. The industrial effluents contain biodegradable organic material; a variety of metals including silver, copper, and zinc; and a list of toxic substances including chlorinated organics and ammonia.

The following processing operations account for most of the industrial effluent, most of which are similar to the processes used at Haley Industries.

- large X-Ray photoprocessing operation contributing silver and spent developer/fixer solutions to the effluent;
- chemical milling and etching of aluminum components using chromic, hydrofluoric, nitric and sulphuric acid baths;
- laboratory waste sources; and
- groundwater containing volatile organic carbon compounds such as trichloroethylene (TCE) and trichloroethane (TCA).

Effluent Treatment and Management

Drawing No. 306 shows the general configuration of the effluent treatment process at Martin Marietta which is designed to treat 3,800 m^3/d and normally operates at about half the peak capacity. The domestic effluent and biologically treatable wastes are collected separately and treated in a two-stage trickling filter process. The final effluent from this process then combines with the remaining process wastes and the entire flow is treated in a series of physical and chemical unit processes designed to remove metals, strip volatile organics, oxidize nitrites and reduce hexavelant chromium. Final treated effluent is



MARTIN MARIETTA ASTRONAUTICS LTD
WATERTON, COLORADO
EFFLUENT MANAGEMENT PROCESS

ONTARIO MINISTRY
OF ENVIRONMENT

BEAK DRAWING NO
91-5070-306

DATE MAY\92

impounded in one of three 1,790 m^3 covered holding tanks and released to the receiving water only after the contents have been analyzed and shown to meet the NPDES Permit requirements for every regulated parameter.

Biological Treatment: The sanitary wastes are collected in an aerated surge tank with a total volume of 1,700 m^3 which is greater than the average daily flow. This allows feed to the trickling filters to be regulated at a relatively constant rate which improves treatment reliability.

Photoprocessing wastes contain thiosulphites and ammonium acetate. Sulphite and acetate exert a BOD_5 and are therefore amenable to biological treatment. A silver recovery system comprising an electrolytic step and an ion exchange step pretreat this waste before it is discharged into the sanitary system. In this way the silver concentration has already been reduced to below 0.004 mg/L so that the ultimate disposal of digested primary and biological sludge is not influenced by silver contamination.

The two step trickling filter arrangement shown in Drawing No. 306 is somewhat unconventional with an intermediate and a final clarifier. Any one of several other conventional biological treatment configurations would operate as effectively if properly designed. The system at Martin Marietta developed over a period of years through a series of facility upgrades.

Industrial Surge Tank: The biologically treated effluent and effluents from three industrial waste sumps are collected in a surge tank upstream of the physical/chemical treatment system. This includes the chemical milling and etching wastes, hydrotesting waste, some general lab wastes and groundwater pumped from a series of fourteen wells in an area contaminated with low concentrations of trichloroethylene and trichloroethane.

Chemical Reduction and Precipitation: Cationic polymer, caustic soda (e.g., to pH=8), and ferrous sulphate are added to a rapid mix tank. This reduces hexavelant chromium to the trivalent form and flocculates metal hydroxides and phosphorous. Fluoride concentrations are also reduced in the rapid mix and subsequent clarification step from about 4 mg/L to between 1.5 and 2.0 mg/L. Lime precipitation was used in the past but was replaced with ferrous iron and caustic soda to reduce the total sludge production by 80-90 percent.

The contents of the rapid mix tank flow by gravity to a circular clarifier where the sludge settles and can be recycled to assist nucleation in the rapid mix tank or pumped to a filter press for dewatering. Anionic polymer and hydrogen peroxide are added to the flow as it enters the clarifier. The peroxide is used to convert residual ferrous ion to the less soluble ferric form to allow removal with the clarifier sludge. Overdosing peroxide can reverse the oxidation/reduction process for chromium so dosing is closely watched.

Sand Filtration: Clarifier effluent flows by gravity through one of two sand filters to reduce suspended solids from about 20 mg/L in the influent to less than 5 mg/L in the effluent.

Nitrite Oxidation: Nitrite is occasionally present in the effluent as a result of incomplete nitrification of ammonia in the biological treatment step. This parameter is regulated and it is sometimes necessary to complete the oxidation to nitrate by reducing the pH to 4 followed by the addition of hydrogen peroxide. This process is rarely used and can cause problems downstream as peroxide residual will attack and cause irreversible damage to the ion exchange resins in the final treatment step.

Air Stripping: Two air strippers in series are used to remove the TCA and the TCE which are present in the groundwater component of the feed stream. The daily mass of TCE and TCA in the exhaust air was sufficiently small that it was not necessary to treat this exhaust.

Carbon Adsorption: Air stripped effluent has its pH adjusted to 5 and then is pumped through two activated carbon columns operating in series. A third column is reserved off line for carbon changeovers. The feed contains about 10 mg/L of TOC and this is decreased to 1 mg/L in the final effluent. Each column contains 9 metric tonnes of carbon which is backwashed once per week to remove trapped solids and replaced once in nine months. Only acid washed virgin carbon is used in the columns to avoid the potential for adding contaminants that may be present in recycled carbon.

Ion Exchange: Ion exchange is the last treatment step in the process and the same selective resin used at the two General Motors plants discussed in Section 6.1 is also used by Martin Marietta. This selectively removes metals such as copper, lead, zinc, silver and cadmium but has little effect on calcium and magnesium. There are two columns which can operate either in series or in parallel and these units have been on more or less continuous duty since May 1991. The total metal load to the system is light and the units had not required regeneration during the first half year of operation.

Ion exchange is bypassed whenever the nitrite oxidation step is in use.

Storage and Batch Discharge: Final treated effluent has its pH adjusted to between 6 and 8 and is then pumped into one of three covered steel storage tanks which are glass lined and agitated. Samples are taken from each tank once it is filled and a complex array of analyses covered by the NPDES Permit is completed to ensure compliance before the batch is discharged.

Capital and Operating Costs

The basic treatment process was already in place in 1986 including biological treatment of the domestic waste and hexavelant chromium reduction and lime precipitation for the industrial waste when a two phased facility improvement plan was authorized. Phase 2 of this project was completed by late 1990 at a total cost of $7.2 million US for treatment facilities. A significant expansion of the laboratory facilities was also completed during this period so that all daily monitoring and routine analyses could be completed on site and within twenty-four hours in the case of the batch analyses of the final treated effluent.

The total annual cost of operations is $2.3 million or about $4.20 per cubic metre of effluent treated. This includes costs for operator labour, laboratory services, disposal of 220 t/y of dewatered hazardous sludge, chemicals and carbon supplies plus maintenance.

The operations staff consists of thirteen employees and there are an additional thirteen laboratory staff.

Contaminant Discharges

Table 6.15 is a summary of the quality of the final treated effluent as discharged by Martin Marietta for the eighteen month period from January 1990 to June 1991. Many of the contaminants listed in the table were routinely near or below the MOE's RMDL concentrations including TSS, copper, cadmium, silver, lead and benzene to name a few.

Phosphorous concentrations averaged 0.2 mg/L which is very low for any treated sanitary effluent. The average ammonia nitrogen concentration was about 10 mg/L which suggests that the two-stage trickling filter system does not provide complete nitrification.

Bioassay monitoring is conducted quarterly by Martin Marietta, usually via acute lethality bioassays for *Ceriodaphnia* and fathead minnows. All reported results since 1990 have been non-lethal.

TABLE A3.1: SUMMARY OF FINAL TREATED EFFLUENT
PLANT: MARTIN MARIETTA ASTRONAUTICS GROUP - STATION 005 (FINAL OUTFALL TO BRUSH CREEK)
SAMPLING PERIOD: JANUARY 1990 - JUNE 1991

				Flow				
Parameter	RMDL (mg/L)	Number Observations	Number Observations Below RMDL	Average (m³/d)	Maximum (m³/d)	Minimum (m³/d)	Average (m³/tonne)	Peak Month Average
Flow	N/A	545	N/A	1,500	3,730	-	N/A	1.13
				Concentration			Average Load	
				Average (mg/L)	Maximum (mg/L)	Minimum (mg/L)	(g/tonne)	(kg/day)
BOD$_5$	5.0	19	5	5.6	13	3.0	N/A	8.2
pH	N/A	545	N/A	7.65	8.9	6.5	N/A	N/A
O/G	1.0	4	2	1.3	3	<1	N/A	1.5
TOC	5.0	16	3	6.4	14	4.0	N/A	9.9
TSS	5.0	43	34	2.0	31	1.0	N/A	3.4
Total P	0.10	43	9	0.21	0.66	0.05	N/A	0.36
Ammonia	0.25	16	0	10.6	15	3.2	N/A	15.2
Fluoride	0.10	27	3	1.6	1.9	1.3	N/A	2.1
Silver	0.030	26	26	0.001	0.0008	0.0001	N/A	0.001
Aluminum	0.030	43	3	0.19	0.54	<0.02	N/A	0.32
Cadmium	0.0020	43	43	-	0.0045	<0.0001	N/A	-
Copper	0.010	43	22	0.011	0.08	<0.01	N/A	0.017
Nickel	0.020	43	42	0.003	0.02	<0.02	N/A	0.005
Lead	0.030	43	43	0.003	<0.03	<0.02	N/A	0.005
Zinc	0.010	43	4	0.062	0.21	<0.01	N/A	0.11
Chromium	0.020	19	7	0.018	0.10	<0.01	N/A	0.026
Cyanide	0.0050	19	9	0.015	0.22	<0.01	N/A	0.023
Benzene	0.00050	19	19	-	<0.001	<0.001	N/A	-
Total Toxic Organics	N/A	19	N/A	0.01	<0.05	<0.05	N/A	0.015
Toxicity	N/A	5		All > 100% for Fathead Minnows and *Ceriodaphnia*. (For data see Appendix 4)				

APPENDIX 4

Toxicity Data

TABLE A4.1: SUMMARY OF TOXICITY DATA

Plant	Organism/Test	Date	Results
Domestic			
General Motors	Rainbow Trout/96-hr LC_{50}	21 May 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	25 June 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	10 July 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	13 August 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	12 September 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	16 October 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	13 November 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	11 December 1990	N.L.
	Daphnia magna/48-hr LC_{50}		<100%
	Rainbow Trout/96-hr LC_{50}	15 January 1991	N.L.
	Daphnia magna/48-hr LC_{50}		<100%
	Rainbow Trout/96-hr LC_{50}	12 February 1991	<100%
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	12 March 1991	N.L.
	Daphnia magna/48-hr LC_{50}		<100%
	Rainbow Trout/96-hr LC_{50}	09 April 1991	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
Ford Motor Co.	N.A.		
Canada Pipe	N.A.		
Crowe Foundry	N.A.		
Franklin Electric	Rainbow Trout/96-hr LC_{50}	August 1990	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	November 1990	<100%
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	February 1991	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	March 1991	N.L.
	Daphnia magna/48-hr LC_{50}		N.L.
Richmond Die Casting	Rainbow Trout/96-hr LC_{50}	N.A.	3 Tests - All N.L.
	Daphnia magna/48-hr LC_{50}		3 Tests - All N.L.
Chrysler Canada	Rainbow Trout/96-hr LC_{50}	N.A.	2 Tests - All N.L.
	Daphnia magna/48-hr LC_{50}		2 Tests - All N.L.

TABLE A4.1: SUMMARY OF TOXICITY DATA

Plant	Organism/Test	Date	Results
Western Foundry*	Rainbow Trout/96-hr LC_{50}	N.A.	2 Tests - All N.L.
	Daphnia magna/48-hr LC_{50}		2 Tests - All N.L.
Canada Alloy	Rainbow Trout/96-hr LC_{50}	N.A.	All N.L.
	Daphnia magna/48-hr LC_{50}		1 < 100%
Kubota	Rainbow Trout/96-hr LC_{50}	N.A.	4 Tests - All N.L.
	Daphnia magna/48-hr LC_{50}		4 Tests - All N.L.
Haley Industries	Rainbow Trout/96-hr LC_{50}	16 May 1990	Invalid
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	13 June 1990	Invalid
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	19 July 1990	89%
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	15 August 1990	N.L.
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	13 September 1990	14%
	Daphnia magna/48-hr LC_{50}		21%
	Rainbow Trout/96-hr LC_{50}	17 October 1990	2%
	Daphnia magna/48-hr LC_{50}		3%
	Rainbow Trout/96-hr LC_{50}	14 November 1990	84%
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	12 December 1990	64%
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	16 January 1991	59%
	Daphnia magna/48-hr LC_{50}		Invalid
	Rainbow Trout/96-hr LC_{50}	13 February 1991	19%
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	13 March 1991	27%
	Daphnia magna/48-hr LC_{50}		N.L.
	Rainbow Trout/96-hr LC_{50}	17 April 1991	14%
	Daphnia magna/48-hr LC_{50}		11%
International			
Waupaca	*Daphnia magna*/48-hr LC_{50}	22 May 1990	N.L.
	Daphnia pulex/48-hr LC_{50}		N.L.
	Fathead Minnow/96-hr LC_{50}		N.L.
	Daphnia magna/48-hr LC_{50}	N.A.	N.L.
	Daphnia pulex/48-hr LC_{50}		N.L.
	Fathead Minnow/96-hr LC_{50}		N.L.
Foundry No. 4	*Ceriodaphnia*/48-hr LC_{50}	N.A.	N.L.
	Fathead Minnow/96-hr LC_{50}		N.L.

TABLE A4.1: SUMMARY OF TOXICITY DATA

Plant	Organism/Test	Date	Results
Indianapolis Foundry	N.A.		
John Deere Foundry	Fathead Minnow/96-hr LC_{50} *Ceriodaphnia*/48-hr LC_{50}	16 October 1990	N.L. N.L.
Auburn Foundry	N.A.		
Mitsubishi Kobe	N.A.		
Martin Marietta	Fathead Minnow/96-hr LC_{50} *Ceriodaphnia*/48-hr LC_{50}	N.A.	5 Tests - All N.L. 5 Tests - All N.L.

N.A. = Not available/applicable.
* = 2 tests at each of two outfalls.